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MULTIPLEX TELEPHONY AND TELEGRAPHY OVER OPEN-CIRCUIT BARE WIRES LAID IN THE EARTH OR SEA.*

BY

MAJOR GENERAL GEORGE O. SQUIER,

Chief Signal Officer, United States Army. Member of the Institute

INTRODUCTION.

THE "key problem" in the procurement of essential Signal Corps supplies in the United States during the World War, curiously enough, turned out to be the production of the necessary braiding machines for finishing insulated wire. The bare wire itself could be obtained, the rubber insulation could be obtained, even the cotton thread with which the braiding was made could be obtained, but the necessary machinery for braiding the thread, which finally led us into the difficulties of the procurement of steel, was never anything like adequate for the enormous demands required in the field.

The braiding capacity of the entire United States, as of September 1, 1918, was sufficient for about 8000 miles of twisted pair insulated wire a month, while the requirements for the American forces alone at that date were about 40,000 miles a month. On October 1, 1918, the Allied Council reached the

* Communicated by the author. An abstract of this paper was presented to the National Academy of Sciences, Washington, D. C. April 27, 1920.

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decision that beginning March 1, 1919, it would be necessary for the United States to furnish all of this type of wire used by the Allied armies in the field, and the estimated minimum requirements for this purpose were 100,000 miles a month. To supply this amount of insulated wire would have required cargo space for overseas shipment in the amount of 14,000 ship tons a month, but had it been possible to use single conductor bare wire in place of the twisted pair insulated wire, the space required would have been reduced to 2500 ship tons a month, thus releasing the balance for transportation of food, and other vitally necessary supplies.

It is, therefore, of paramount importance to diagnose, as far as possible, the technical problems of equipment in the light of past experience and of the present trend of development.

The above facts show the necessity of developing, if possible, new methods by which a reduction may be effected in the enormous quantities of expensive and bulky insulated wire, which was so difficult to procure during the World War.

The following reasoning led to the carrying out of the experiments to be described.

1. Since we can already communicate by radio means between one submarine and another submarine, both completely submerged, it was considered that connecting two such stations by a submerged copper wire could have no other effect than to facilitate the propagation of the electromagnetic waves between the stations.

2. It was considered possible that earth or water under the action of high frequency electromagnetic forces might exhibit greatly different properties from those with which we are familiar at direct or low frequency currents.

3. It was believed that whatever high frequency energy losses might occur in the transmission over bare wires laid in earth or water, the over-all efficiency would be higher than in the case of radio space transmission where the plant efficiency is so very low.

4. It was noted by the writer in September, 1910, and discussed by him in April, 1912,[1] that the three electrode audion could be used as a potentially operated device on open circuits. This arrangement was considered suitable for the reception of the signals over bare wires in earth or water.

[1] JOURNAL OF THE FRANKLIN INSTITUTE, April, 1912, "Some Experiments in 'Wired Wireless' Telegraphy for Field Lines of Information for Military Purposes," by Major George O. Squier, Signal Corps, U. S. Army.

PRELIMINARY EXPERIMENTS.

The first experiment was an extremely simple one, as follows: A bare No. 18 phosphor bronze wire, such as is used for Signal Corps field antennæ, was laid across the Washington channel of the Potomac River from the War College to the opposite shore in Potomac Park. It was paid out from a small boat with sufficient slack to lay on the bottom of the river. Care was taken to make this preliminary experiment as simple as possible, and precaution was taken to insure that the wire itself should be bright and clean and entirely free from any grease or other insulating material. A standard Signal Corps radio telephone and telegraph set, SCR 67, was directly connected to each end of the wire, one set serving as a transmitter and the other as a receiver. At the receiving end of the line the bare wire was directly connected to the grid terminal of an electron tube in the receiving set and the usual ground connection left open. A frequency of about 600,000 cycles a second was used and the line tuned at each end by the usual methods. Excellent telegraphy and telephony were obtained.

This experiment demonstrated the possibility of transmitting electromagnetic waves along bare wires submerged in water, and the use of an electron tube as a potentially operated device on open wire for the reception of signals.

The success of this simple experiment led immediately to a more thorough consideration of the entire subject.

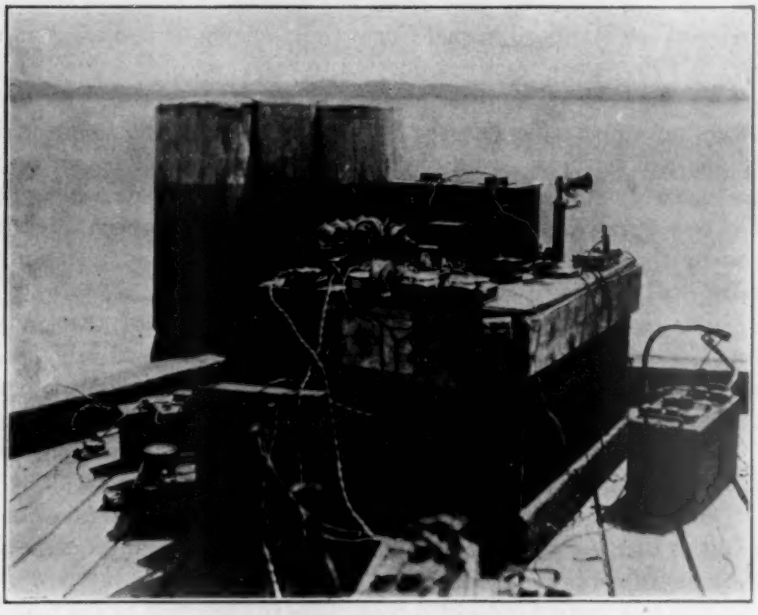
One of the questions to be investigated was the general effectiveness of the electron tube when used as a potentially operated instrument connected to an open line.

The following experiment was made in the office of the Chief Signal Officer, Washington, D. C. A strip of wire netting was buried in the snow outside, with a wire attached to it leading to the second story of the office. The upper end of this wire was connected directly to the grid of an electron tube. The reason for connecting the grid to the upper end of the antenna is, of course, obvious. For maximum sensitiveness it is necessary to connect it to the point of maximum potential of the antenna, which in the case of a linear oscillator occurs at the open end. By this arrangement, messages were readily received from distant points in the United States.

THE PROPAGATION OF ELECTROMAGNETIC WAVES OVER BARE WIRES IMMERSED IN WATER.

A series of tests was arranged to check more carefully the results of the preliminary experiments and also to get more complete information on the possibilities of the method of using bare wires submerged in water for high frequency current telegraph and telephone communication. The tests were conducted between Fort Hunt, Virginia, and Fort Washington, Maryland, located on

PHOTOGRAPH A.

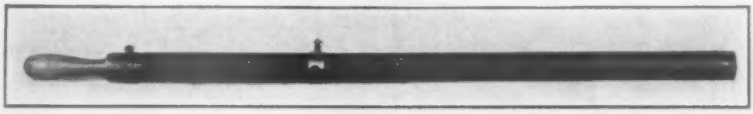


opposite banks of the Potomac River, approximately twenty-five miles south of Washington. The wire consisted of a bare seven-strand No. 18 phosphor-bronze antenna wire submerged for approximately 3000 feet (914 m.). The two terminals were brought out on the wharves where the transmitting and receiving apparatus were located, as near as possible to the surface of the water as shown in the accompanying photograph "A." The length of the exposed portion of the wire at the transmitting end was about 7 feet (2.1 m.), while at the receiving end it varied from 5 to 25 feet (1.5 m. to 7.6 m.), depending upon the location of the receiving apparatus in the various experiments.

TRANSMITTING DATA.

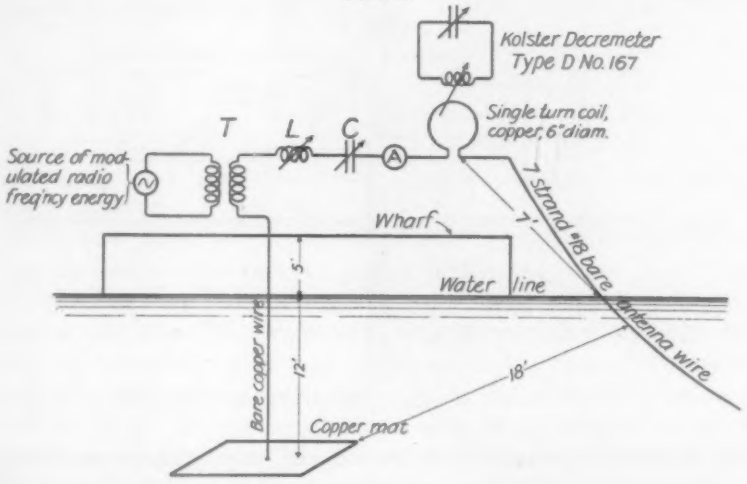
The transmitter was located on the Fort Hunt wharf on the Virginia side of the Potomac. It was of the electron tube type oscillator with Signal Corps VT-2 tubes. The particular type of circuit employed was developed especially for wired wireless transmission and possesses features which make it directly applic-

PHOTOGRAPH B.



able to this type of work. Buzzer or voice modulation was also provided for, the modulating circuit being identical with that employed in the standard Signal Corps radio telephone apparatus. The source of modulated high frequency energy was coupled to

FIG. 1.



the submerged wire as shown in Fig. 1, where the source is shown at the left, T is a radio frequency transformer, L a variable inductance, C a variable condenser. A transmitting wave-length of 1050 metres was adopted as this was very closely the wave-length for which the amplifier at the receiver was designed. The tuning of the submerged wire by means

of the variable inductance and capacity was remarkably sharp, a definite maximum value of current being obtained, which at resonance averaged 250 milliampères. In general, the line behaved as a lumped inductance rather than a capacity; a variable condenser in series is necessary to tune this line. At this frequency the line was found to have an equivalent inductance of about .02 of a millihenry.

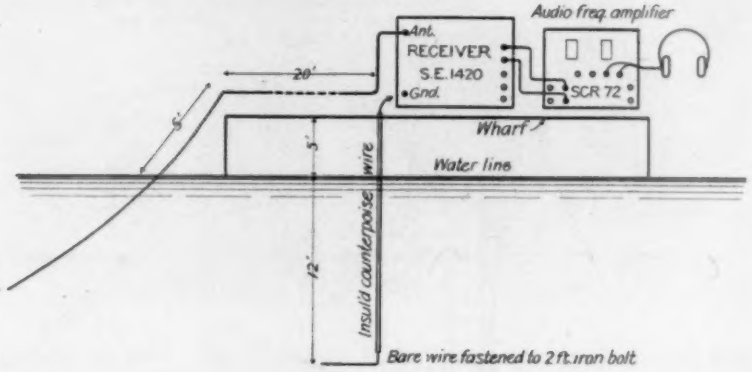
RECEIVING DATA.

The receiving apparatus was located at Fort Washington, Maryland, on the east bank of the Potomac River.

Test No. 1.

A Navy type SE-1420 radio receiver, and a Signal Corps SCR-72 audio frequency amplifier were employed. The schematic arrangement is shown in Fig. 2. The circuits of this receiver are inductively coupled, the secondary having a wave-

FIG. 2.



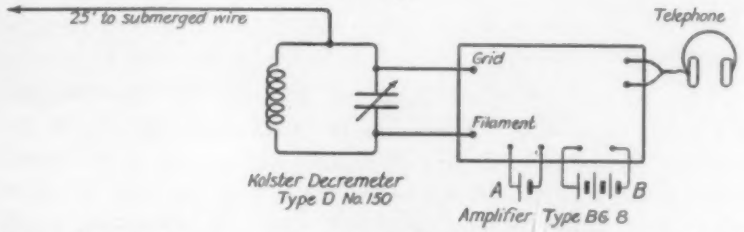
length range of 200 to 8000 metres, and may be made oscillatory or not at will. With the connections indicated in the figure, and with the ground connections either on or off, *no signals were received* in an oscillating circuit receiver when the distant transmitter was unmodulated or in a non-oscillating receiver when the transmitter was modulated by a buzzer or the voice. Both spark and continuous wave signals, however, were received from nearby radio stations when the ground connection was removed.

Test No. 2.

A simplified circuit was next used connected as shown in Fig. 3, consisting of a simple oscillatory circuit, the bare wire being connected to one terminal of the condenser and to the grid.

A Signal Corps type BC-8 amplifier, consisting of three stages radio frequency amplification, one detector tube, and two stages audio frequency amplification was used. The radio circuits of the amplifier were at resonance at 1050 metres. With this arrangement both buzzer modulated signals and speech were received from the transmitting set at the other end of the submerged wire. The tuning at the receiving end was sharp. Signals from radio stations were also received. Connecting the ground mat to the input filament terminal of the amplifier completely eliminated all signals. With the submerged wire connected direct to

FIG. 3.



the grid and the oscillating circuit removed, no signals were received.

In both of the above tests the receiving apparatus was located approximately five feet (1.5 m.) above the water level, and twenty feet (6.1 m.) horizontally from the actual terminal of the submerged wire. To determine to what extent the exposed twenty feet of horizontal wire was acting as an "antenna," the entire receiving apparatus was moved close to the terminal of the submerged wire, the exposed portion thus being reduced in length to approximately five feet (1.5 m.). Under this condition, the intensity of the received signals *was considerably reduced.* Replacing the exposed twenty feet (6.1 m.) of wire, and moving the apparatus back to its original position did not, however, bring back the signal to its original strength. Later investigation of this point showed that at this time, trouble developed in the modulating circuit at the transmitter, which accounted for the weakening of the signals, and therefore was not due to the short-

ening of the exposed wire. Disconnecting the submerged wire, with or without the twenty feet (6.1 m.) of exposed wire attached to the circuit totally eliminated all signals. This demonstrated that with the apparatus and circuits employed, the signals received were transmitted over the submerged bare wire connecting the two stations, and, that the " antenna effect " of the short length of exposed wire at the receiver was entirely negligible.

Test No. 3.

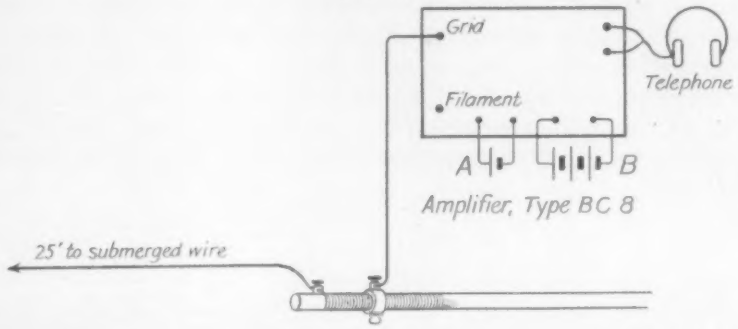
An experiment was tried in which the submerged wire was connected direct to the grid input terminal of the amplifier. It was found, however, that the latter " howled " so badly as to prevent the distinguishing of any signals. Shunting the input terminals of the amplifier with a capacity of about 200 M.M.F. eliminated the howling and brought in signals from the transmitter.

Test No. 4.

The submerged wire was led directly to one terminal of a single layer coil. The diameter of this coil was 1½ inches (3.8 cms.), wound with No. 36 double silk-covered wire, length approximately 28¼ inches (71.75 cms.), total number of turns, 4100. The other terminal was left free. A brass ring about one-half inch (1.27 cms.) wide, split longitudinally and provided with a binding post and small rubber knob, could be slid over the coil for the purpose of locating points of loop potential on the coil. This ring or band was completely insulated from the coil winding. A short flexible lead connected this band to the input grid terminal of the amplifier used in the preceding experiments. The circuit is shown diagramatically in Fig. 4. Standing waves were found to exist on the coil, and the buzzer signals were received. Two potential loop points were noted on the coil; the one giving the louder signals being that nearer the free end of the coil. The coil was turned in a horizontal plane while connected to the submerged wire, but no directional effects were observed. As in the previous experiment, to eliminate howling, it became necessary to shunt the input terminals of the amplifier with a small capacity. Radio signals from nearby land stations, and telephone conversation from a Navy airplane in flight were heard by this method.

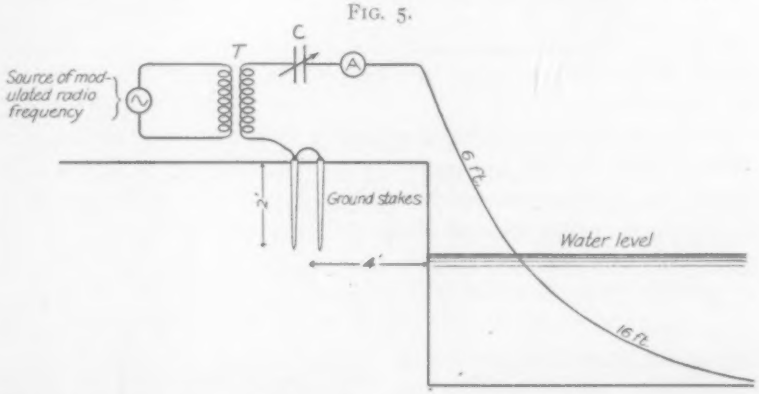
To make certain that in the above experiments the bare wire constitutes the necessary connecting link between the two stations through which the high frequency current flow takes place, and that the energy is not in some way transmitted entirely or in part

FIG. 4.



through the body or over the surface of the water, the following experiment was made. The connections are shown in Fig. 5. The line consisted of a bare copper wire approximately 22 feet (6.7 m.) in length, of which 16 feet (4.9 m.) were submerged in

FIG. 5.

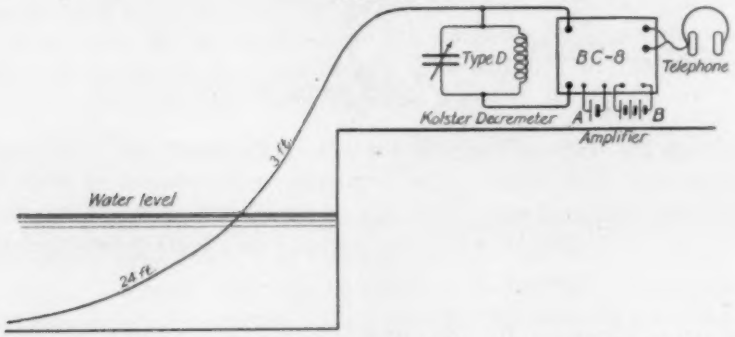


the water, the outer end of which was left free. The other terminal was connected to two metallic ground stakes buried in the earth to a distance of about 2 feet (0.61 m.). The average distance between the ground stakes and the water was about 4 feet (1.2 m.). The transmitting wave-length was 1050 metres, as in the Fort Hunt-Fort Washington tests, and maximum cur-

rent obtainable 200 milliampères. In contrast to the results obtained in the preceding tests, it was impossible to get any marked resonant effect with this short submerged wire. As the series capacity, *C*, Fig. 5, was increased, the line current slowly increased but did not, however, reach a resonant maximum value.

The receiving apparatus used was identical with that employed in the preceding test. The distance separating the two stations was approximately 2000 feet (0.6 km.). At the receiver, the line consisted of 27 feet (8.2 m.) of bare wire, of which 24 feet (7.3 m.) were immersed in the water, leaving 3 feet (0.9 m.) exposed. A type D Kolster decremeter and a type BC-8 Signal

FIG. 6.



Corps amplifier served as a receiver, the connections being as shown in Fig. 6.

With this arrangement, employing no ground connection, and with the transmitter operating as described, using buzzer modulation, no signals were received. Employing the submerged wire as a ground, and a wire of about 60 feet (18.3 m.) in length laid upon the stone sea wall as an antenna, time signals were received from the Navy Station at Arlington, Virginia, but no signals were received from the transmitter at the other side of the river. Using the connection shown in Fig. 6, it was impossible to receive signals even from the Arlington Station.

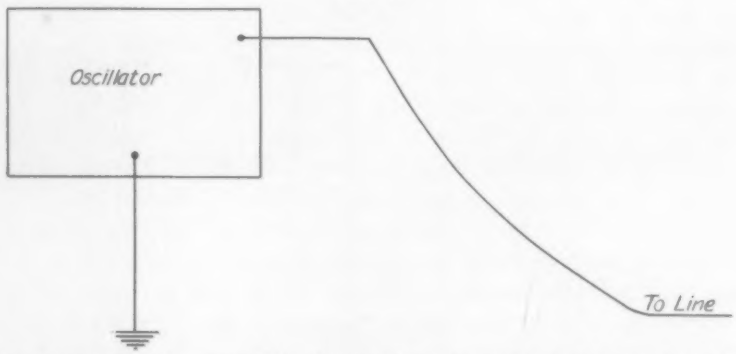
It is evident from the negative results of the above test, that the high frequency current flow must be confined more or less to the bare wire connecting the two stations. We are not prepared at this time to offer any explanation regarding the actual mechanism of the energy transfer. It may well be that the bare wire functions as a guide, the electromagnetic energy being con-

fined to a finite cylindrical layer of water surrounding the wire. But whatever the true explanation may prove to be, it was established by these experiments that high frequency currents can be transmitted on bare wires submerged in fresh water.

EXPERIMENTS WITH BARE WIRES LAID ON THE GROUND.

The Signal Corps is now required to furnish lines of intercommunication in each of the three media, *viz.*, air, earth and water, or any combination of these. As examples: (1) one airplane to another airplane, (2) one military dugout to another military dugout, and (3) one submarine to another submarine, both submerged. The earth crust consists of such widely differ-

FIG. 7.



ent character of materials, depending upon the locality, that the propagation of electromagnetic waves in this medium should in general differ with the particular character of the earth. Water, on the other hand, being a much more homogeneous medium, should exhibit more regular and orderly results, and this in general has been the experience thus far in these experiments.

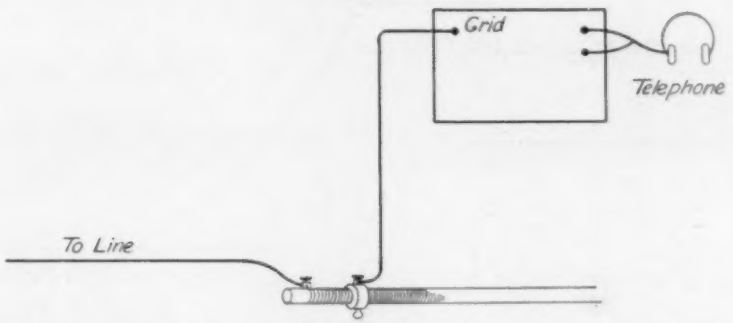
The work at the radio laboratories at Camp Alfred Vail, Little Silver, New Jersey, was confined to experiments on the propagation of electromagnetic waves over bare wires laid on the surface of the earth or completely buried in the earth, the object being a study of the effect of the earth as a surrounding medium. Many experiments were made to obtain information of the various factors which may have an influence on the final results. It would make this paper too voluminous if an atempt were made to recount here in detail all of the experiments. It will suffice,

therefore, to give only a general summary of the methods employed and the results obtained.

No attempt has been made to determine to what distance these methods may be made effective for the transmission of messages.

Tests were carried on between the main laboratory and a small field laboratory one and three-quarters miles distant (2.8 km.). A bare No. 16 wire was laid on the surface of the earth connecting these two stations. The radio telephone instruments used at each end were the standard Signal Corps SCR-67 sets, which comprise an oscillating transmitter of the electron tube type. The schematic diagrams of the transmitter and the receiver are shown in Figs. 7 and 8. The transmitting current was about 100 milliampères at any of the wave-lengths available with these sets,

FIG. 8.



which covered a range of approximately 200 to 550 metres. Good telephone communication could be maintained between these two stations with the above equipments.

Tests were also made to ascertain if any standing wave formation occurs on the line. The method used was to get the current intensity at different points on the line by opening it at different points and inserting a hot wire milliammeter. At distant points where the current was very small, the hot wire milliammeter was replaced by a low resistance thermo-couple and a single pivot Paul microammeter. It was found that the current continually decreased with the distance from the transmitting end. The line was then cut at a point three-eighths of a mile (0.6 km.) distant from the transmitting station and left open. Ammeters inserted at intervals along this section of the line at once indicated the existence of standing waves. An investigation was then made with a search

coil circuit consisting of a small loop tuned by a variable condenser and an electron tube detector and two-stage amplifier. By moving this coil along the line the loops and nodes of the standing waves were located. The wave-length used in these tests was 250 metres, and the transmitting current about 120 milliampères.

BARE WIRES BURIED IN THE EARTH.

Experiments were also made at Little Silver, New Jersey, connecting two stations by a bare wire buried in the earth at a depth of about eight inches (20 cm.). A furrow was plowed between the two stations and a bare No. 16 wire was then laid in this furrow; a second furrow was plowed back along the side of the first one, so that the earth from the second furrow was turned back into the first, covering the wire. The soil is moist, sandy loam, being only a few feet above tidewater. Signal Corps SCR-67 radio sets were used for transmitting and receiving purposes, one connected at each end of the buried wire. With this arrangement telephone and telegraph communication was established over a distance of about a half mile (0.8 km.). In general at the frequencies used the line behaved as an inductance.

In the case of the propagation of high frequency currents over bare wires laid on the surface of the earth or buried in the earth, the electromagnetic energy associated with it is apparently confined only to a limited region surrounding the wire. If a bare wire, open at the receiving end, whether laid on the surface of the earth or buried in the earth, were considered as a radio antenna, it would be expected that signals would be heard in a region along the prolongation of the wire in a direction opposite to the open end, in accordance with the well-known phenomena relating to directive antennæ. As a matter of fact, however, the experiments showed just the reverse. Signals were always located in close proximity to the wire itself, and followed it about through angles or in straight lines as the wire was laid.

Another remarkable effect observed in connection with the experiments on the propagation of high frequency currents over buried wires was the influence of a comparatively thin layer of soil in screening the electromagnetic effects due to the current flow in the wire. The following experiment was made: Signals were transmitted over the bare buried wire, and an exploring

coil, with a suitable detecting instrument, was moved along the buried wire at a fixed distance from it. It was found that by uncovered a short length, say 5 feet (1.5 m.), of the wire immediately beneath the coil the signals would appear, and would disappear again when the earth was put back over the wire. From a military standpoint this screening effect of comparatively thin layers of certain kinds of soil is evidently very important. It serves to separate and isolate certain radio phenomena on bare wires in earth to secure secrecy which is so necessary for military purposes, and so difficult and well-nigh impossible to obtain in the air.

MULTIPLEXING.

No special mention has been made of the multiplex features in connection with these open circuit lines, whether buried in earth or water. It is self-evident that the general principles of multiplexing over wires in air by using radio frequency carriers are also applicable to wires in earth or water.

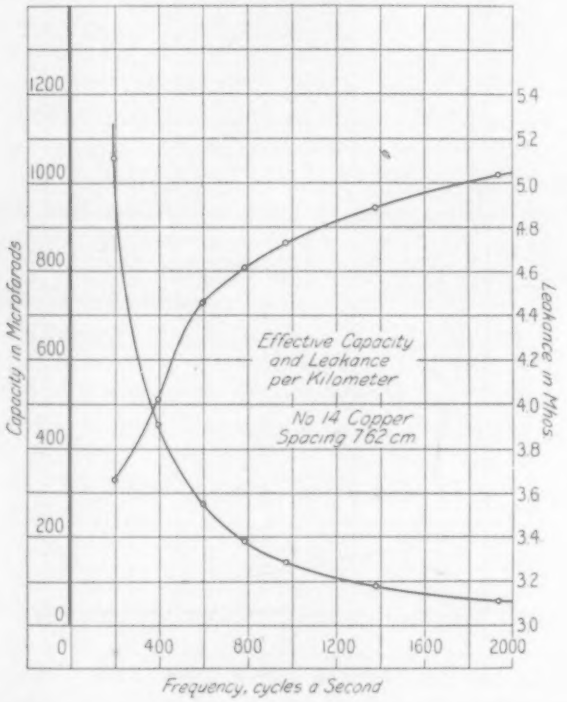
BUREAU OF STANDARDS EXPERIMENTS.

A detailed laboratory study of the phenomena connected with the propagation of high frequency currents on bare wires submerged in fresh water is also being conducted in the Signal Corps research laboratory at the Bureau of Standards. The object of these researches is to determine the electrical constants of bare wire submerged in water when subjected to high frequency currents. A suitable tank for this purpose was available at the Bureau, the dimensions of which are as follows: 125 metres long, 2 metres deep and 2 metres wide. Two wires were placed in the tank, serving as a to-and-fro conductor, and constituting a complete transmission line immersed in water. An electron tube oscillator was used as a transmitter and measurements were made to determine the apparent impedance of the system with the remote end short-circuited and also open-circuited. From these measurements the electrical constants of the line were calculated. The research has not been completed yet, but the information obtained in regard to the capacity and leakance may be of considerable interest, and are accordingly given here in the accompanying curves, Figs. 9 and 10. It is seen that at low frequencies the capacity is extremely large, about 1200 microfarads per kilometre, the equivalent of an entire Atlantic cable, but dimin-

ishes very rapidly as the frequency is increased, and at a frequency of about 40,000 cycles a second, the capacity practically vanishes. The leakance increases with the frequency up to about 5000, and then begins to slowly decrease as the frequency is increased. Experiments are now being conducted at still higher frequencies.

The results were surprising, particularly the high capacity

FIG. 9.



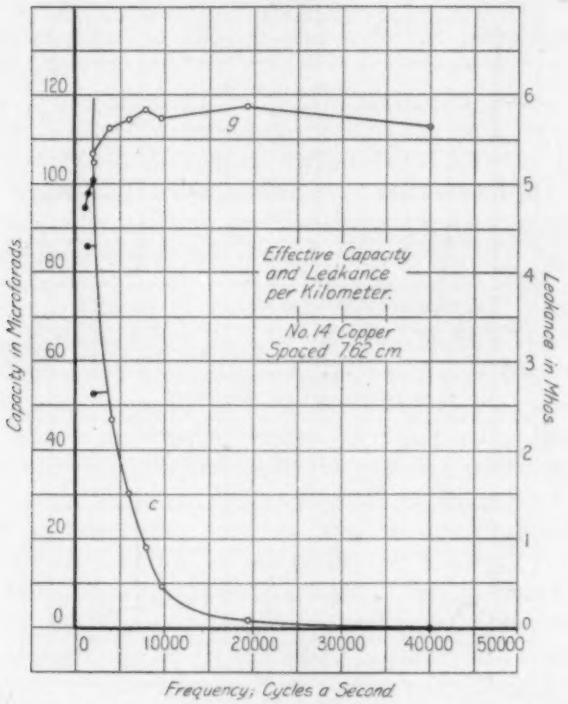
values at the low frequencies. The experiments apparently show that the frequency of the current used has a marked influence on the behavior of water as a medium, and is entirely different from what it would be for direct or low frequency currents.

It must be noted, however, that in the calculation of the values given, the usual transmission formulæ were employed, which may not be applicable in this case. It is expected, however, that further experiments will be made under resonance conditions, and at still higher frequencies.

RESONANCE WAVE COILS.

In the investigation of the problems discussed in the preceding sections, open circuits were used and the electron tube employed as a potentially operated device, the grid being directly connected to the line. To get the best results, it was necessary to devise a method for securing high potential points at the receiving end of the line without losing the advantage of tuning. This

FIG. 10.



was accomplished by the use of a resonance wave coil connected to the line, and adjustment obtained by either moving along the coil the end of the wire connected to the grid, or sliding along the coil, a narrow metal ring connected to the grid, this constituting a capacity coupling between the grid terminal and the coil. Coils of various dimensions were made up of wave-length ranges from 250 metres to 1800 metres. A separate study of the electrical characteristics of these coils as a means for receiving radio signals is being conducted in the Signal Corps laboratories.

For the present purpose it will suffice to give here only a general statement in regard to the characteristics of the resonance wave coil receivers and the results obtained. The coils were made up in the form of long helices uniformly wound with very fine wire so as to give uniformly distributed inductance, capacity and resistance, except for the disturbing end effect. The inductance per unit length is high and, therefore, in a comparatively short coil, the equivalent condition of a long line is obtained in the matter of wave development. As an illustration we may give the data for one coil as follows: Diameter, 11.5 cm.; length, 58 cm.; number of turns per cm., 34; total inductance of coil calculated, 80.5 millihenrys; fundamental wave-length measured, 1700 metres. Such a coil connected to an antenna or bare wire in water or earth, as in these experiments, can be used for tuning and at the same time advantage can be taken of the wave development on the coil, and the highest potential point used for obtaining the greatest sensitiveness in the receiving of the signals. This is practically the way in which the wave coils were used in the experiments described above.

Aside, however, from its use as a tuning element in connection with antennæ or lines, it was found in the course of the experiments that a resonance wave coil can also function as the antenna, so that by itself it constitutes a complete antenna system. The coil may be grounded at one end or it may be entirely free. In either form it can be utilized as a means for receiving radio signals.

It may be noted that in an antenna of this kind all the electrical constants, inductance, capacity, resistance and the e.m.f. induced in it by the incoming signal are of a distributed character, which makes it in a sense an ideal wave conductor.

No complete data is yet available in regard to sensitiveness and selectivity of the wave coil antenna as contrasted with the usual forms of closed circuits now used. Very promising results, however, are being obtained in the Signal Corps laboratories and the study of the electrical characteristics of the wave coil is being continued.

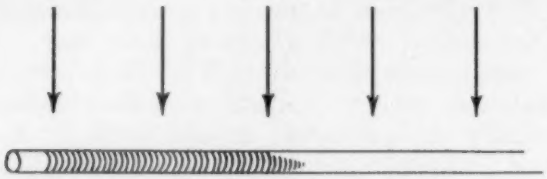
DIRECTION FINDING.

The experiments with the resonance wave coils led to the discovery that it possesses remarkable directive properties. A change in the position of the coil with respect to the transmitting

source changes the voltage and current distribution on the coil and accordingly produces a shift in the position of the point of maximum potential. The shift occurs in one direction or the other, depending on the position of the transmitting source with respect to the coil. Hence, this offers a means of determining not only the plane in which the electromagnetic waves travel, as is the case of the usual loop antenna, but it determines the actual direction from which the signals proceed. The explanation appears to be as follows:

If the electromagnetic wave front is parallel to the axis of the coil, as indicated diagrammatically in Fig. 11, each element of the coil has induced in it an e.m.f. of the same intensity and the same phase. We have a condition of a conductor of uniformly distributed electrical constants, and acted upon by uniformly distributed e.m.f., from which results a definite potential and current wave distribution on the coil, the exact form depending on the length of the coil, frequency, and terminal conditions. By moving the terminal of the grid of an electron tube along the coil,

FIG. 11.

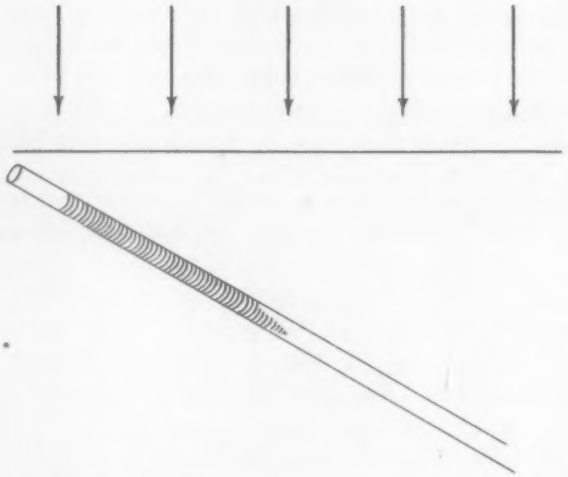


the point of maximum potential is readily determined. The connection between the grid and the coil need not be an actual physical contact. In most experiments a capacity connection was used, consisting of a narrow metal ring sliding freely on the coil. If now the coil is turned at some angle, as shown in Fig. 12, the e.m.f. induced in the coil is no longer uniformly distributed, since there is a difference of phase between the e.m.f. acting on each element of the coil arising from the difference in time required for the electromagnetic wave to reach the different parts of the coil. As a result, the voltage and current distribution on the coil is altered and the point of the maximum potential loop is accordingly shifted in one direction or another, depending on the direction of inclination of the coil to the direction of propagation of the signal. It was also found that when the longitudinal axis of the coil is perpendicular to the direction of propagation of the sig-

nals two potential loops may occur, one near each end of the coil, these potential loops being substantially of the same amplitude. When the coil is turned through an angle in the horizontal plane the potential loop near that end of the coil which points in the general direction towards the transmitting source is of a greater amplitude than that of the loop near the end of the coil pointing away from the station. This, therefore, offers a suitable means for determining the actual direction from which the signals proceed.

The above is only a brief statement of the general principles

FIG. 12.



governing the operation of resonance wave coils as applied to direction finding.

SUMMARY.

For military reasons, if for no other, as stated in the introduction of this paper, the Signal Corps has recently undertaken certain investigations in the phenomena connected with the transmission of high frequency electromagnetic waves over bare wires in earth and in water.

In attacking the problem from various angles and in carrying out these investigations the research staff of the Signal Corps laboratory at Camp Alfred Vail, Little Silver, New Jersey, was directed to carry out experiments on bare wires laid on the surface of moist ground and also buried in earth. The staff at the

Signal Corps research laboratory at the Bureau of Standards was directed to investigate fundamentally the transmission of electromagnetic waves over bare wires in fresh water. In addition to this, the engineering staff of the office of the Chief Signal Officer has carried out from time to time certain experiments of a more or less crucial character which have come up for solution in the prosecution of this work at the other laboratories.

Certain data from each of these groups of engineers have been presented above. The phenomena associated with the transmission of high frequency waves over bare wires in earth or water are obscure and complex, and the writer has formulated no definite theory at the present time.

RESULTS OBTAINED.

1. Telephone and telegraph communication has been established between Fort Washington, Maryland, and Fort Hunt, Virginia, across the Potomac River, below the City of Washington, over a distance of about three-quarters of a mile (1.20 km.), by the use of a bare No. 12 phosphor-bronze wire laid in the water to connect the stations. The transmitter consisted of an electron tube oscillator which delivered a current of about 270 milliampères to the line at a frequency of about 300,000 cycles a second. At the receiving end of the line an electron tube and a six-stage amplifier were used without any ground connection. With this arrangement good tuning was obtained at both ends of the line, and telegraphic and telephonic transmission secured over the bare wires immersed in fresh water.

2. A resonance wave coil has been developed. The coil is in the form of a long helix wound with a large number of turns on which stationary waves are produced by the incoming radio signals. An electron tube is used as the detector, the grid being connected to the point of maximum potential on the coil. The wave coil may be used either as a part of the usual antenna system or a part of a line wire, or it may act itself as the antenna for picking up the energy of the signals. In the latter case the coil may be either free at both ends or grounded at one end. Good results have been obtained in either case. It has been also found that the open coil has directional properties and can be used as a goniometer. This form of radio goniometer has the great advantage that it permits not only of determining the plane where

the signals are strongest but also the direction from which such signals proceed.

3. Telegraph and telephone communication has been also established between two stations at the Signal Corps research laboratories at Camp Alfred Vail, Little Silver, New Jersey, using a bare No. 16 copper wire buried in the earth to a depth of about eight inches (20 cm.) to connect the stations. The distance between the two stations was three-quarters of a mile (1.20 km.). Frequencies as high as one million cycles a second were used. Similar communication has been carried on over a bare wire one and three-quarters miles (2.8 km.) long laid on the surface of moist earth. The current at the transmitting station in these installations was about 100 milliampères. It has been shown that a bare wire buried in moist earth with the distant end open can be tuned both at the transmitting end and at the receiving end.

SUGGESTIONS.

1. In the older art of ocean telegraphy, the elaborateness of line construction has already reached a practical limit. The best Atlantic cable of the present day is limited in operation to electric waves of frequency of the order of 10 cycles a second. The electrical construction is such as to limit the voltage employed on any long cable to from 50 to 80. The relative values of the line constants in any present ocean cable preclude the possibility of ocean telephony.

The most promising hope of improving the line construction for ocean cables is believed to be to abandon the present method of design and construction and to start with the simple case of bare wires in water using high frequency currents and study the necessary changes to produce optimum transmission.

The use of a high frequency "carrier" has the inherent advantage that the distortion phenomena accompanying present methods of long-distance transmission are eliminated, and we are principally concerned with the problem of reducing attenuation. The most suitable voltage may be employed and present multiplex methods may be utilized. The electron tube is available for both the generation and the reception of the waves.

2. During the last few years an intensive study has been made of the surface conditions of wires necessary to produce the emission of electrons, and to this intensive study, both by uni-

versities and industrial research laboratories, is due the high state of efficiency of the present electron tube. Nothing short of a similar study of the surface conditions of wires to prevent the emission of electrons instead of producing them, will finally give us the wire conductor of the future.

3. The development of types of resonance wave coils, both open at one end and at both ends, for general radio work offers an interesting field for investigation. This involves the study of the electron tube as a potentially operated device. The application of such coils properly designed for specific purposes may lead to the practical solution of a number of radio problems such as directional effects, and wave coils antennæ of very small dimensions.

4. The account of the experiments thus far conducted and the reasons which have led to the undertaking of these experiments on the part of the Signal Corps, are presented to the National Academy of Sciences at this time in conformity with the new spirit of organization for national and international research so admirably typified by the National Research Council which is under the general direction of this official body.

OFFICE OF THE CHIEF SIGNAL OFFICER,
WAR DEPARTMENT,
WASHINGTON, D. C.,
April 27, 1920.

The Spectral Distribution of the Radiant Energy of Metals. G. R. GREENSLADE. (*Physical Review*, February, 1920.)—A thin sheet of the metal was bent into a V. Working temperatures were got by directing an optical pyrometer into the V, while the outer surface of the strip radiated to the receiving device, a reflecting spectrometer and bolometer. Very instructive curves are given for iron, tungsten, and molybdenum in which wave-length is plotted against intensity of radiation for eight or more temperatures. The purity of the metal was discovered to affect greatly both the form of this curve and also the total energy radiated. "One specimen of commercial nickel at 1353° K. had a total emission of 2.5 times that of electrolytic cobalt-free nickel at the same temperature, and the energy for the wave-length of maximum emission was 3.0 times as great. This large difference was probably due to contamination of the surface by the ash contained in the impure specimen."

G. F. S.

U. S. NAVAL AIRCRAFT.*

BY

JEROME C. HUNSAKER, Eng.D.

Commander, Construction Corps, U. S. Navy, Navy Department, Washington, D. C.

IN the few years that Naval Aircraft have been part of the Navy they have become so specialized by adaptation to meet specific naval requirements that they constitute to-day distinctive types of design. Before considering these peculiarly naval types, let us examine the naval functions which have governed their development.

The Navy consists of two major parts: the Fleet, which is designed to operate on the high seas in any part of the world, and the Shore Establishment, organized as Naval Districts on the coasts of the United States and the outlying possessions. The primary function of the Fleet is to discover, engage and destroy the enemy fleet. The functions of the Shore Establishment are both industrial and military. The industrial function does not concern us here. The military function is the elimination from coastal waters of the activities of enemy naval forces, in particular, raiders, submarines and mine-layers.

The Navy employs every weapon or device which is considered to be useful in connection with its mission. As the mechanical arts advance, the latest applications are introduced. Progress in any of the arts or sciences is eagerly seized upon to discover means for making use of the new knowledge in the Navy. So with aeronautics; as the art has progressed, aircraft have been developed for use in the Navy. The principles governing the design of such Naval Aircraft are the very fundamentals of the art, but the aircraft themselves represent the application of these principles to meet the needs of the Navy; that is, to fulfill functions allied to the functions of the Fleet and the Shore Establishment.

Consider the Fleet first. The Fleet must have scouts to discover the enemy and give intelligence of his strength and

* Presented at the joint meeting of the Institute and the Aero Club of Pennsylvania held Wednesday, January 21, 1920.

probable intentions. Aircraft may obviously be used for this purpose in conjunction with scout cruisers, destroyers, or battle cruisers. The range of visibility from aircraft is relatively enormous, as an observer in an airplane can go three times as fast and see three times as far as an observer on a ship. With this inherent advantage, it only remains to develop practical scouting or reconnaissance aircraft for such work. This development results from no idle arm-chair speculation, however, as the problem is limited by the restriction that the Fleet is normally at sea and the weather normally bad.

Scouting, or reconnaissance for the Fleet, may be of two kinds: First, reconnaissance at a great distance, requiring great endurance in the air; and second, reconnaissance at a short distance immediately in advance of the Fleet. For this second function, great endurance is not needed as a frequent return to the parent ship is possible. We thus will have at least two types, one characterized by extreme endurance, the other by simplicity and handiness for use from shipboard.

Another distinct type must be employed for fighting enemy aircraft which, in any future naval engagement, will surely be present. This problem presents considerable difficulty as it presupposes a battle in the sky for control of the air in advance of the actual engagement of the ships. Control of the air over a wide area can only be maintained by large numbers of airplanes of the greatest fighting capacity and the launching of a swarm of airplanes at the desired moment from the restricted spaces aboard ship seems impracticable. Consequently, special ships in the Fleet with flush decks and enormous hold spaces are necessary to act as carriers.

Before the introduction of aircraft into the Fleet, the control of gunfire was directed by a "spotter" stationed on the mast. This is the highest point on the ship from which to observe the splash of the shells, but compared with a position several thousand feet in the air, it is very low—too low, for example, to see over a smoke screen made by enemy destroyers, and too low to estimate at extreme ranges the distance from the target to the splash. The individual battleships of the Fleet have need, therefore, for aircraft to carry the fire control officer or spotter aloft.

The aircraft so far discussed are primarily concerned with air fighting and observation. There remains the offensive func-

tion which is the primary objective—to destroy the enemy fleet. Aircraft can now carry bombs powerful enough to damage a battleship or a regulation torpedo sufficient to sink her. Torpedo attack from the air cannot be stopped by the usually effective screen of destroyers and light cruisers. In fog or at night the great speed of torpedo-carrying airplanes adds so much to the element of surprise that the chances greatly favor the attack. Further-

FIG. 1.

Ship's fighting plane flying off turret platform. (U. S. Navy.)

more, booms, nets and chains across a harbor mouth will no longer render the anchorage immune from attack. The torpedo plane during the War was not developed to full effectiveness by either side, but in any future war we may expect it to play an important part.

To recapitulate, there are five essentially distinct functions for aircraft with the Fleet:

1. Long-range scouting.
2. Short-range scouting.

3. Fighting in the air.
4. Spotting or control of gunfire.
5. Bomb and torpedo attack.

The Shore Establishment divided into Naval Districts has, likewise, uses for aircraft in connection with the control of coastal waters. The first and most important is searching for

FIG. 2.

Ship's fighting plane after a water "landing." Note inflated air bags. (U. S. Navy.)

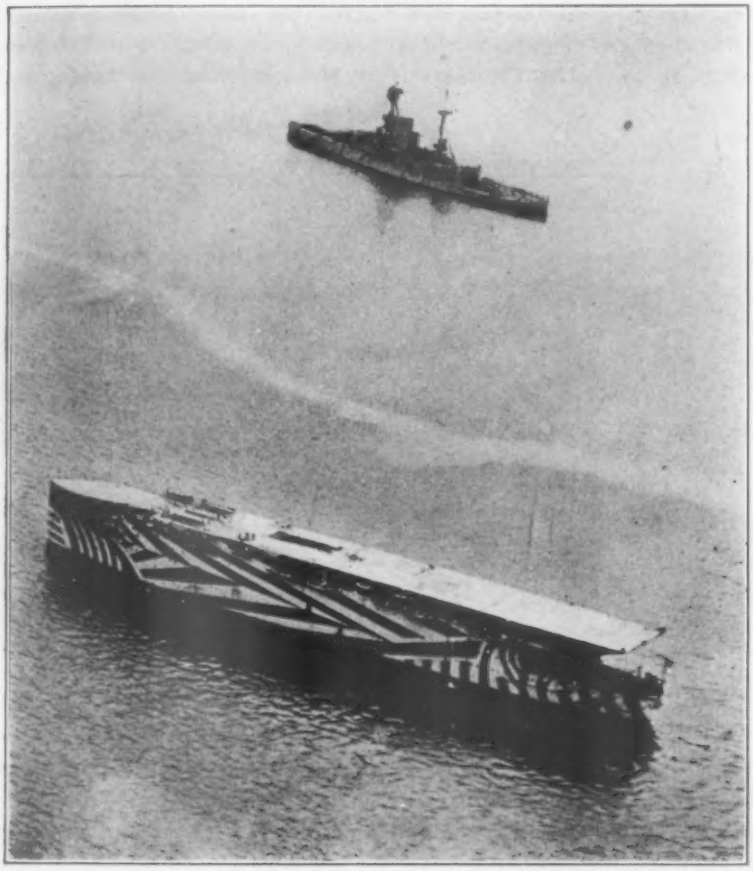
hostile raiders, submarines, mine-layers, etc., which duty may be termed "Coast Patrol."

In connection with coast patrol it may become necessary to convoy shipping into and out of ports and through dangerous waters. For this purpose aircraft are essential, not alone of course, but coöperating with an escorting force of destroyers.

In addition to the applications of aircraft mentioned so far, we have very necessary aircraft work required in connection with Advanced Base and Expeditionary Forces. Such Expeditionary Forces may usually be supposed to operate without opposition

from a highly developed air force, but such a favorable condition cannot be guaranteed. The Marines, therefore, have to be provided with the latest thing in military airplanes. Such types are similar in function and hence in design to those used by an

Fig. 3.



H. M. S. *Argus*, airplane carrier. (British Navy.)

army, and I shall not take time to discuss them as Naval Aircraft.

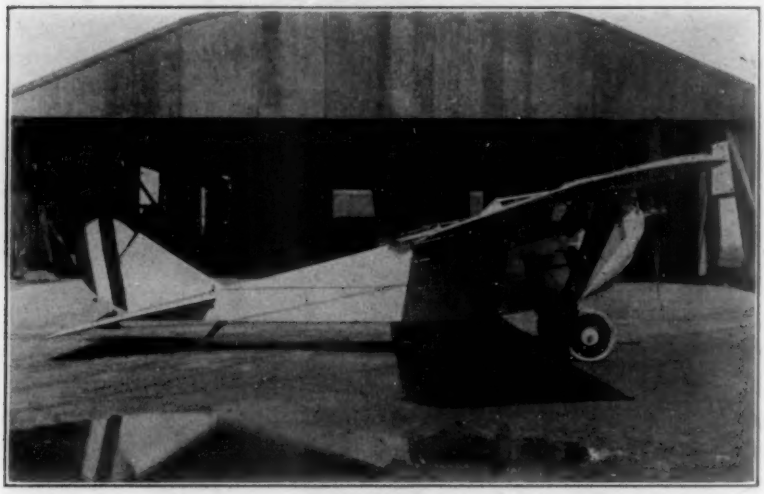
In the foregoing, I have briefly classified aircraft functions as based on the functions of the Navy. In considering how aircraft can fulfill these functions we are immediately confronted

with the necessity for deciding whether we require "heavier-than-air" or "lighter-than-air" types.

Under "heavier-than-air" we include all airplanes and seaplanes which are supported by their own wings. By "lighter-than-air" we designate balloons and airships or dirigibles. Kites and parachutes are not classified as aircraft.

Among "heavier-than-air" craft, we have: First, airplanes with wheels of the ordinary type; second, seaplanes with floats or pontoons to fit them to start from and alight on the water; and

FIG. 4.



Ship's spotting plane. (U. S. Navy.)

third, flying boats, being a true boat fitted with wings. These types may be somewhat mixed in special designs as, for example, a seaplane provided with wheels as well as floats to make it amphibious, or an airplane fitted with hydro-vanes and air-bags to permit emergency alighting on the water.

"Lighter-than-air" craft consist of the ordinary free balloons, or "sphericals," kite balloons of elongated form which are towed by a cable, non-rigid airships (or dirigibles) obtaining lift from a gas-bag under pressure, and rigid airships such as the Zeppelin with a rigid hull structure fitted with a multiplicity of gas-bags.

In the present state of the art we may choose one type or the other for a certain naval function, depending on clearly evident practical considerations, but for others, it is not clear whether we should favor an airship or a large seaplane. The final decision can only be made after experience with each, but by that time progress in the art may require a reversal of the conclusions reached. It is wise, therefore, to provide both and allow the stimulation of competition to develop the possibilities of each.

Let us now look at the types of aircraft already in use, and

Fig. 5.

Ship's spotting plane. Same machine as Fig. 4, fitted with floats. (U. S. Navy.)

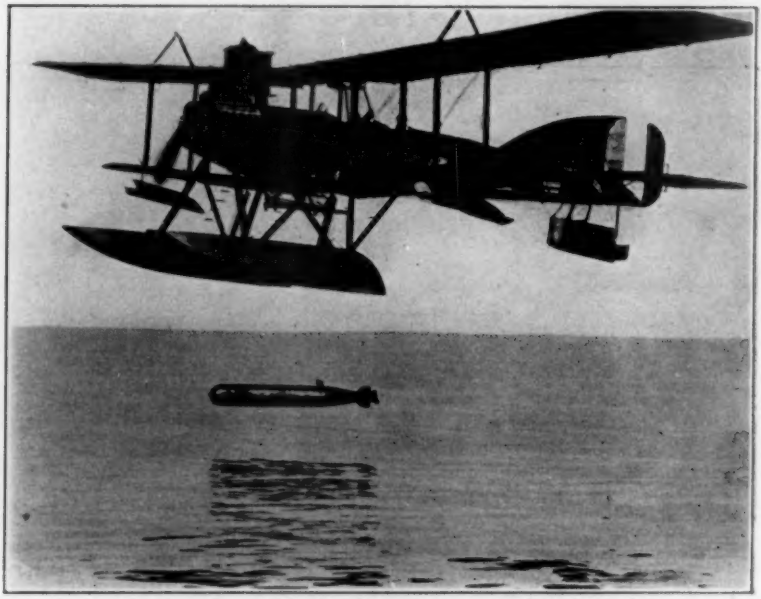
consider what is the state of the art, the requirements of the service, and the possibilities for meeting them in the immediate future.

For long-distance scouting at sea, it is primarily a question of the greatest endurance and radius of action. There is no aircraft which approaches the rigid airship in these characteristics. The present-day German and British rigids of 2,000,000 cubic feet volume have a maximum radius of action of over 3000 miles and can stay out about five days. The best that has been done to date with a flying boat is about 1500 miles. While the radius seems to be half that of the airship, the comparison is less favorable when it is considered that the flying boat cannot keep in the air quite a day. On the other hand, the airship can

drift about while waiting or observing without consumption of fuel; the crew are comfortable and probably will do better work; radio is more powerful and communication with the Fleet more certain.

The rigid airship, according to Admiral Jellicoe, is worth two light cruisers for scouting in favorable weather. The last words must be pondered, for " favorable weather " is a relative

FIG. 6.



Torpedo plane at instant of launching torpedo. (British Navy.)

term. Fog is no doubt most unfavorable weather for a seaman, but for an airship at sea low fog may give it a distinct advantage in scouting. The airship will, however, have to cope with storms and heavy rain and snow. Due to her great endurance and the usually local character of really violent meteorological disturbances, the airship can be expected to avoid getting into trouble. Naturally, we must assume adequate weather reports by radio from the ships coöperating with her. However, the necessity to avoid storm centres will put a stop to any scouting for the time being. A flying boat is relatively unaffected by storms while

in the air, but she cannot alight on the water under such conditions. With present power plants such a possibility must always be kept in view.

The latest German rigid airships have a maximum speed of about 70 land miles per hour and the NC-4 flying boat has a top speed of about 90 miles per hour. To cope with gales of general extent the airship is clearly at a disadvantage. It is

FIG. 7.

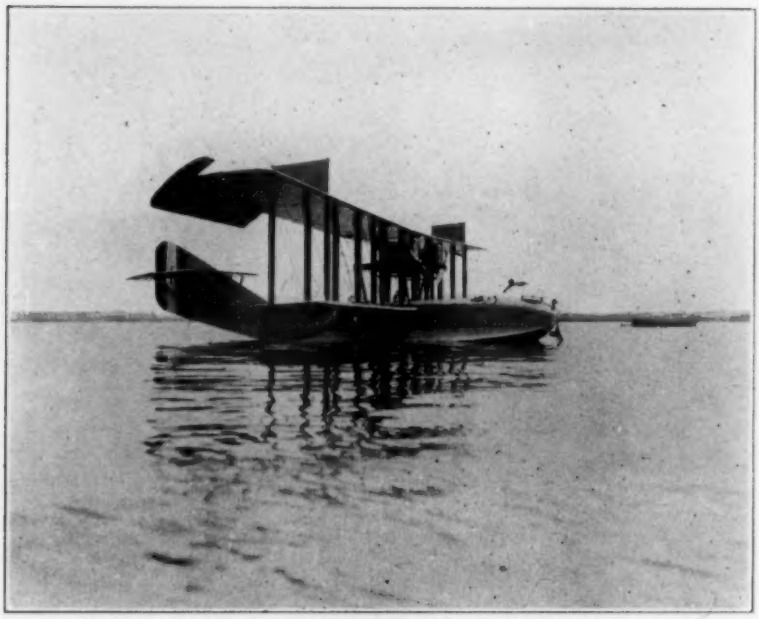
Coast patrol and convoy type. Flying boat F-5 at start. (U. S. Navy.)

probable that, following the present trend of design, the airship speed will not be pushed much, if any, above 80 miles, while a speed of 115 miles for the flying boat is already in view. It seems evident that the relative utility of the airship and flying boat depends upon weather conditions. For scouting over the North Atlantic in seasons of high winds, the flying boat may be the more suitable.

I have not here considered large land type airplanes which, while comparable with large flying boats in speed and endurance

in the air, are unfit to send out to sea, as they cannot land to refuel or make repairs, but must make non-stop flights from land to land. The scouting requirements of the Fleet are unlikely to be always in waters conveniently near the aerodrome. The flying boat will have to be based on shore for hauling out and overhaul, but normally she will follow the fleet, being supplied with fuel from a supply ship, except in rough weather, when she will take refuge in

FIG. 8.



Coast patrol and convoy type. Flying boat F-5 at anchor. (U. S. Navy.)

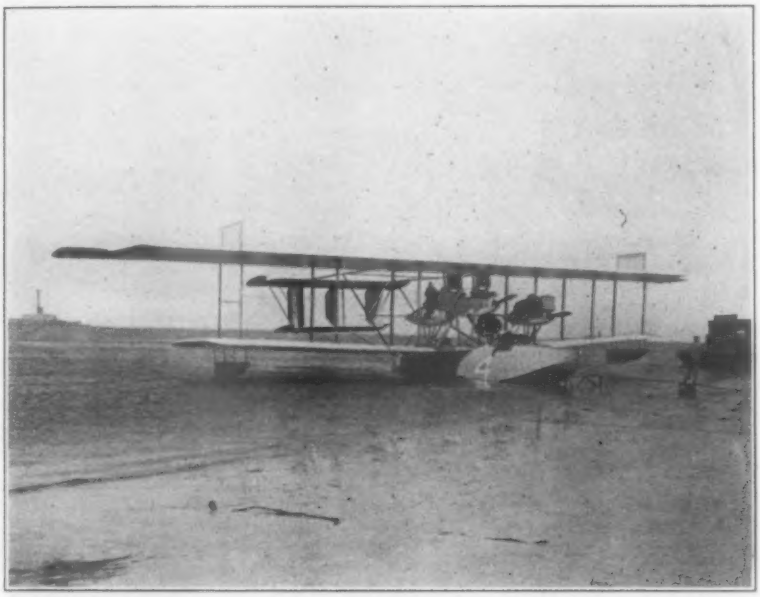
the nearest sheltered water like any small craft. There is no need for an expensive and elaborate chain of landing fields, as all the bays and rivers of the world are "landing" spots more level than the most perfect field on shore.

The rigid airship, like the airplane, must start from and return to a land base, but her five-day endurance minimizes this restriction. There must be, however, airship bases located at all strategic points near which the Fleet is likely to operate.

The cost is interesting for comparison. The rigid airship

of the greatest size yet constructed costs about twenty times as much as the NC-4, the largest flying boat yet built. The shed to house her also costs about twenty times as much as housing on shore for NC-4. Considering cost alone, we should hope the airship were as useful as twenty flying boats. Under some conditions this may be the case. Any number of flying boats bringing in negative reports is worthless compared with continuous positive

FIG. 9.



Flying boat NC-4, long range scouting type. (U. S. Navy.)

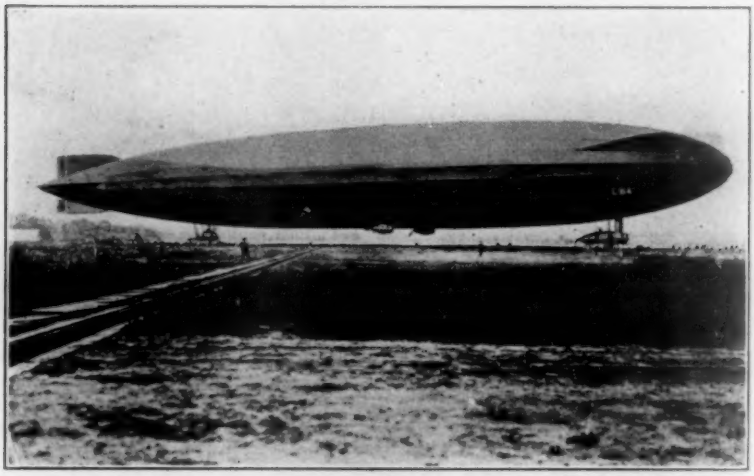
and definite information from an airship keeping the enemy under constant surveillance.

It must not be forgotten that the rigid airship of the present day is very vulnerable to attack from airplanes, as has been demonstrated over London to the entire satisfaction of the Germans. The German bombing raids over London were entirely unjustifiable, either on grounds of ordinary decency or from tactical considerations. The legitimate function of the Zeppelin was scouting over the North Sea where most valuable work was

done. Indeed, on more than one occasion, the Zeppelin scouts permitted the German High Seas Fleet to avoid action and certain defeat by the British Grand Fleet.

It is hoped that at some future day helium may become cheap enough to be used in place of hydrogen. Until that time comes, rigid airships must avoid coming within the range of enemy ships or aircraft. At sea, with its immense distances this is quite possible to accomplish. There is no need to come within range of a ship's guns in order to observe its movements and, in general, airplanes can be avoided by rising into the clouds.

FIG. 10.



Zeppelin L-64. (German Navy.)

The airship, at high altitudes, can rise faster than an airplane as the latter climbs by engine power, which is becoming weak, while the former climbs by dumping ballast, which is always effective. Furthermore, at high altitudes, the airship suffers no loss in speed while the airplane, no matter how fast at sea level, loses speed rapidly with altitude. During the chase of an airship, it is also to be remembered that the airplane may come under the fire of several guns of the airship. On the whole, the airship should be able to keep clear of hostile aircraft.

The present state of the art indicates the rigid airship and the large flying boat as rivals as scouts for the Fleet. The rigid

airship in its latest development is represented by the Zeppelin and the flying boat by the NC-4 type of our own Navy. Is it likely that the possibilities of the immediate future indicate any important change in the relative merits of the two types?

Curiously enough, it has been proposed to build a rigid airship twice the size of the present-day Zeppelins and at the same time the flying boat adherents have proposed to double the NC-4.

Fig. 11.

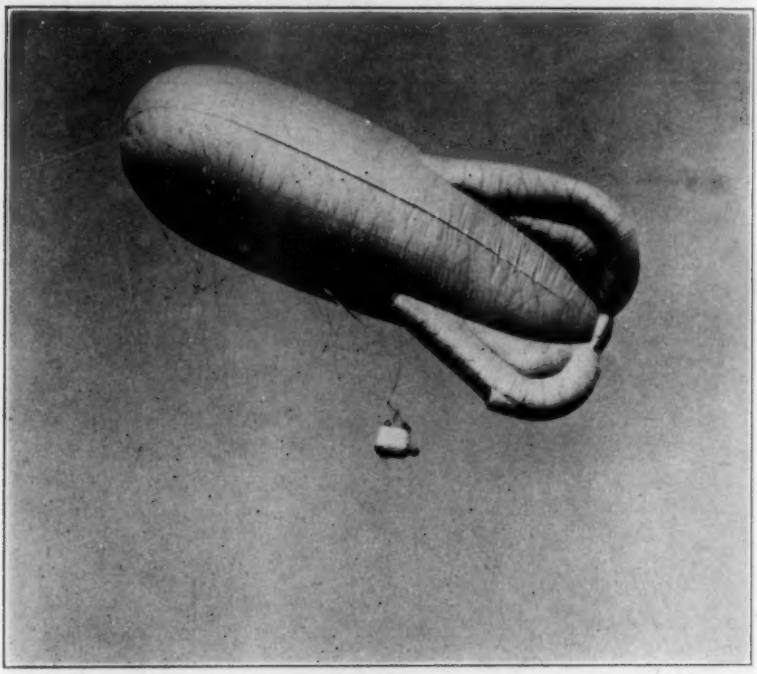
Non-rigid airship C-1. (U. S. Navy.)

Such an increase in size at one step appears to be the maximum it is safe to attempt and it will probably take the next few years to see light ahead. From a preliminary analysis, however, it appears that increase in size is more favorable to the airship than to the flying boat, and as we build larger and larger airships the flying boat is left farther behind.

I shall not burden this paper with the detailed analysis, but fundamentally the difference results from the fact that for the airship the buoyancy of the hull is increased as the cube of a linear

dimension, while for flying boat wings the lift remains the same per square foot or increases as the square only. As airships are made larger the margin of the total lift available to carry fuel and stores is increasing, and an endurance of seven or eight thousand miles is not difficult to reach with an airship of about

FIG. 12.



Kite balloon. (U. S. Navy.)

4,000,000 cubic feet. In other words, by doubling the size of the airship the endurance may be doubled.

On the other hand, the flying boat, if doubled in size, will be likely to add but 25 or 50 per cent. to its endurance. The large flying boat has a decreasing margin of lift available for fuel and stores and an increase in size is uneconomical unless the greater size permits use of better structural arrangements, or better structural material to such an extent as to overcome the unfavorable factors which are inherent in the problem. The effort of the designer will be to provide the larger flying boat with no worse

a ratio between useful load and total weight than we have to-day on the NC-4.

The principal advantage of the large airship as compared with the large flying boat is derived from more economical propulsion. The resistance to propulsion of an airship is largely due to the hull or envelope and it is known from wind tunnel experiment and confirmed by experience that this resistance is represented by an expression of the form:

$$R = KS^{n/2}V^{n}$$

where n lies between 1.86 and 2, and near 1.9. To simplify the argument, let us take $n = 2$, on the safe side. Then $R = KSV^2$ where S is the "wetted surface" or surface exposed to air friction, V the velocity and K a coefficient depending on form. The resistance thus varies as the square of a linear dimension and the square of the speed. The necessary power of the engine is:

$$P \sim KL^2V^3$$

But the lift depends on the total volume which varies as L^3 and hence the tons of weight per horse-power vary as:

$$\frac{\text{Lift}}{\text{Power}} \sim \frac{L^3}{KL^2V^3} \sim \frac{L}{KV^3}$$

For larger ships this ratio becomes more favorable. Since the proportion of the total lift available to carry fuel is known to be more favorable in such large ships as have been built, it is on the safe side to consider such proportion constant for purposes of argument. The weight of fuel then varies as the total lift or as L^3. The endurance in hours is the quotient of fuel available and fuel consumed per hour. This quotient is proportional to the ratio given above, or to tons per horse-power:

$$\frac{L}{KV^3}$$

The larger ship will go farther at the same speed in a manner at least directly proportional to the length.

As a matter of fact, experience has shown that the larger ships actually have a greater fraction of the total lift available for fuel. Nor is the resistance so high as assumed. Therefore, the increased endurance of larger airships is even greater than would be predicted from this simple analysis.

The following table of German Zeppelins, illustrates a progressive improvement with size, but it cannot be expected that such improvement will be continued indefinitely at the same rate, for we should eventually reach a ship such that the empty weight was practically nothing. The rather abnormal improvement shown is due to the fact that the early ships were the small ones and their design was rather crude and heavy. The larger ships are late designs of great refinement. However, the improvement is significant:

Type	Date	Volume cubic feet, 100 per cent. full	Length, feet	Diameter, feet	Lift		Useful	B. H. P., total	Speed, full power, M. P. H.	Endurance	
					Gross tons	Useful tons	Gross, per cent.			Full power, miles	Half power, miles
L-1	1912	793,000	517	48.5	22.8	....	....	540	47	....	....
L-2	1913	918,000	525	54.0	26.4	7.3	27.6	800	49	1100	1750
L-3-9 inc.	1915-16	919,000	525	54.0	26.4	....	....	800	49	....	....
L-31-38 inc.	1916-17	1,945,000	643	78.7	56	26	46.5	1440	60	3200	5050
L-30, 40, 43, 45 and 47	1917-18	1,945,000	643	78.7	56	28.6	51	1440	60	3300	5200
L-44, L-46	1917	1,945,000	643	78.7	56	29.5	53	1200	62	4200	6700
L-48-52 inc.	1917-18	1,945,000	643	78.7	56	30	54	1200	62	4652	7350
L-53-64 inc.	1917-18	1,974,000	643	78.7	57	29	51	1500	68	3950	6300
L-70	1918	2,200,000	693	78.7	63.4	35.7	56	2100	80	3900	6300
L-71	1918	2,420,000	743.1	78.7	70	42	60	1800	74	4800	7600
Bodensee	1919	706,300	393.7	61.3	20.3	7.3	36	1040	80.7	1550	2500
R-38 (British)	1921	2,724,000	694.4	86	78.6	45.9	58.4	1950	70	5100	8100

The flying boat cannot be studied in exactly the same manner as the total lift is given, not by the volume of gas, but by the wings. The lift of an aeroplane wing is represented by an expression of the form:

$$\text{Lift} = KSV^2 f(i)$$

where S is the area, V the velocity, K a coefficient depending on the form of the wing and $f(i)$ a function of the angle of attack, i of the wind on the lower side of the wing. It is an experimental fact, so far without adequate explanation, that an aeroplane wing is useful only between angles of 0 and 14 degrees about. Near 14 degrees, there is a change in the nature of the flow over the wing and violent turbulence is set up. For an angle greater than this critical angle the lift is no greater, and may even be less, while the resistance or drag becomes relatively enormous. Consequently, the aeroplane gets its practical maximum of lift at about 14°, and for a given weight to be carried can fly slowest at this altitude. Since the plane must get up to this speed by a

run on the ground or over the surface of the water, before she will take the air, this limiting speed is the speed of starting and must be kept within practical limits.

For airplanes of the land type the starting speed is between 45 and 55 miles per hour. If anyone has ever attempted to drive an automobile over a pasture or meadow at such speed, he will have an idea of the risk and danger of getting into the air with a large airplane.

The conditions for a seaplane are somewhat more favorable because the water is more nearly level than the average pasture. With modern boat hulls (like the NC-4) a get-away speed of over 60 miles per hour is quite permissible even in rough water. The seaplane or flying boat can, therefore, carry into the air a greater weight for a given wing area simply because the speed can be permitted to go up.

In general, however, the starting and landing speeds of all heavier-than-air craft are restricted by practical considerations and for this reason we may assume that the minimum velocity in the expression, $\text{Lift} = KSV^2f(i)$ a maximum, remains substantially constant.

If we build larger flying boats, the ratio $\frac{\text{Lift}}{\text{Surface}}$, therefore, remains constant. The wing area must increase directly as the total weight of the machine.

The weight of larger wings carrying the same unit load of, say, 9 or 10 lbs. per sq. ft., naturally tends to increase faster than the area of such wings. The larger wings have a greater spread and are more difficult to brace and keep stiff and strong.

The carrying capacity of a wing increases with the square of a linear dimension, but the structural members of which it is composed vary, some as L^2, some as L^3, and some even as L^4. The simple geometrical expansion of a small wing to make a large one would be bad engineering.

Fortunately, one need not be discouraged by such theoretical considerations as we have learned from past experience that, by the introduction of new and better structural materials and arrangements in larger wings, the weight can be kept down nearly to direct proportionality. That is: the weight of large wings per unit area is the same as for small ones carrying the same unit load.

This result, quite at variance with the theoretical deductions of several learned writers, is illustrated by the following table:

Name of machine	W (Gross weight)	A (Wing area)	$\frac{W}{A}$	Weight of wings per square foot (including struts and wires)
R–6	3,964	613	6.4	1.32
HS–1–L	5,902	653	9.0	1.78
HS–2–L	6,373	803	7.9	1.69
H–16	10,900	1,164	9.36	1.76
Caproni	12,810	1,420	9.02	1.15
F–5–L	13,000	1,397	9.3	1.81
F–3	13,400	1,425	9.4	1.70
F–6–L	13,514	1,397	9.7	1.55
NC–2	22,600	2,441	9.3	1.59
NC–4	28,000	2,441	11.5	1.59
Tarrant	44,862	4,950	9.06	1.93

The variations in the weight of wing structure per square foot of area are no more than would be expected from the different designers of these widely differing machines. A point of interest not brought out in the table is that the structural factor of safety has fallen from 6 in the HS type to 3 in the NC type. This sacrifice is necessary in order to avoid weight. It is also justified in view of the fact that the very large machines are not called on to perform acrobatic movements in the air.

After the wings, the next principal weight group to consider is the hull. The hull of a flying boat is designed to float the machine on the water with sufficient reserve buoyancy to give stability and seaworthiness in a seaway. In addition, the hull must afford hydroplaning surface enough to permit high speed over the water at the "take-off." Experiments in the towing tank, confirmed by practical experience, show that all the requirements for a flying boat hull are met if the volume of the hull is kept directly proportional to the total weight of the machine. That is to say, the lines of a large hull may be expanded from the lines of a small one with a scale ratio equal to the cube root of the displacement. The structural weights of such hulls will be almost directly as their displacements, or as L^3, where L is any linear dimension. There is, therefore, little relative gain in hull weight in the larger boats.

An analysis of the weights of a number of large land machines indicates that the weight of fuselage and landing gear is about the same as the weight of the equivalent flying boat hull which combines the two functions.

The power plant weight depends of course on the speed required. Very fast fighting planes may have abnormally big engines which will account for an abnormally large proportion of the total weight lifted. Eliminating these, as well as abnormally slow-training machines, we have the following table from which it seems clear that the percentage power plant is independent of size:

Name of machine	W (Gross weight)	$H.P.$ (Total power)	w (Power plant weight)	$\frac{W}{\text{H. P.}}$	$\frac{w}{W}$ (per cent.)	$\frac{w}{\text{H. P.}}$
R-6	3,964	200	1,159	19.8	29.2	5.77
HS-1-L	5,902	360	1,566	16.4	26.5	4.33
HS-2-L	6,373	360	1,600	17.7	25.1	4.41
H-16	10,900	720	2,831	15.1	26.0	3.92
Caproni	12,810	1,080	4,400	11.8	34.5	4.07
F-5-L	13,000	720	2,876	18.1	22.8	3.98
F-3	13,400	700	2,939	19.1	21.9	4.2
F-6-L	13,514	720	2,893	18.8	21.4	4.01
NC-2	22,600	1,080	5,674	20.9	25.1	5.24
NC-4	28,000	1,600	7,448	17.5	26.6	4.65
Tarrant	44,862	3,000	9,217	15.0	20.6	3.07

Excepting the Caproni, which is obviously over-engined, the table shows that the power plant for general utility machines of long endurance amounts to about 25 per cent. of the total weight and the power plant itself weighs about 4 pounds per horse-power. This includes the complete power plant with all accessories, piping, and auxiliaries.

The figure for the ratio, total weight lifted per horse-power, is about 18 for long-distance flying boats, and while it may vary between 15 and 20 in different designs, such variation is independent of size. We may safely conclude from this survey of past experience (as well as from an analysis based on dimensional theory which I shall not attempt here) that the ratio $\frac{W}{P}$ is substantially constant for large flying boats.

Since the weight of the power plant increases as the gross weight of the planes, and we have seen above that the weight of boat hull and wings increase at least as rapidly, the empty weight of the complete plane should also increase as rapidly as the gross weight lifted. The difference between weight empty and gross weight is the useful load available for crew, fuel, cargo, etc. The useful load should be, therefore, a constant fraction of the gross weight. The following table bears out this statement:

Name of machine	W (Gross weight)	V (Useful load)	$\frac{V}{W}$ (Per cent.)
R-6	3,964	844	22.3
HS-1-L	5,902	1,832	31.1
HS-2-L	6,373	2,113	33.1
H-16	10,900	3,500	32.1
Caproni	12,810	5,110	39.8
F-5-L	13,000	4,750	36.4
F-3	13,400	5,479	40.9
F-6-L	13,514	5,755	42.6
NC-2	22,600	8,900	39.4
NC-4	28,000	12,000	42.8
Tarrant	44,862	18,745	41.8

In this comparison, I have not labored the point as to whether a large seaplane or a large landplane is more advantageous. Without burdening the paper with further tables, I can state that there is essentially no difference between them. The large landplane can be made somewhat lighter structurally than the flying boat, but due to the necessity for providing a slower landing speed the wings must be larger and, hence, heavier. The net result is practically to make the types equivalent in large sizes.

To revert to the comparison with airships, we have the flying boat's power proportional to total weight or to L^3 and, likewise, the useful load or margin available to carry fuel. Consequently, the endurance which is the quotient of these quantities is independent of size and remains constant so far as the effect of size alone is concerned. Practically, the larger flying boats do, however, have a somewhat greater endurance, but this is not due to size but to greater refinement in design. With very large boats it is possible to increase slightly the efficiency of propulsion by using geared-down propellers of large diameter and by more careful reduction of resistance to propulsion. Also the weight of crew and navigational equipment in a large boat is a smaller proportion of the total lift. All economies taken together may give an increase of some 30 per cent. in endurance. No further substantial increase can be expected without material improvement in weight and economy of engines. Naturally, such improvements are expected but cannot be counted on to-day in a design to be built to-morrow. Mere size is not itself going to give great endurance.

On the other hand, we saw how the endurance of the airship increased at least as rapidly as the length. To get greater endurance we need only build larger and, keeping the speed constant,

we get automatically relatively enormous increases in endurance.

We can conclude from all this that for Fleet Scouting at sea where long distances are covered, the rigid airship will be the only suitable type of aircraft. Where the distances to be covered are not too great, where the winds are high, and where hostile aircraft are numerous and efficient, the rigid airship yields first choice to the large flying boat of the "Giant" type, to use the word applied by the Germans, to their 1918 machines.

For daylight patrols over coastal waters a large flying boat is more useful than an airship because a greater area can be searched in given time and because less affected by weather. However, it is often cheaper to use a large number of moderate size flying boats for short patrols.

For convoy work, the flying boat is altogether too fast and of too short endurance. To keep in company with a convoy of vessels proceeding at 10 or 12 knots, the airship is most suitable and for this duty a large number of the cheaper non-rigid airships is more economical to employ than the more costly rigids. The latter should be reserved for Fleet Scouting.

The ship's fighting plane must be carried aboard ship and hence is as small and compact as possible. It is mounted on a platform over a turret and when the ship steams into the wind, the plane flies off in a run of some 40 feet. To be sure of getting off, the plane must be light with relatively large wings. The Army fighting planes are not at all suitable for this work, because they require a long run to get into the air. Furthermore, the Navy ship's fighting plane may have to land in the water in case of engine failure. To permit this, the planes are fitted with emergency flotation gear consisting of vanes, to keep the plane from somersaulting, and air-bags inflated from a bottle of compressed air carried in the plane. Normally, the air-bags are tightly rolled up. The air-bags and vanes are provided instead of regular pontoons to save weight. The fighting plane cannot return to her parent ship directly, but must land on the deck of a special flush deckship called a "Carrier."

The ship's spotting plane is similar to the fighter, except that it is a two-seater of less speed and greater endurance. It is to some extent a general utility machine, and provided with guns to fight off hostile aircraft. The spotting plane may be either a land machine with air-bags or a seaplane.

The torpedo and bombing plane is a larger machine equipped to carry heavy bombs or a torpedo. It will be launched from the carrier. The development of the torpedo plane and the tactics involved in its employment, I am not permitted to discuss in detail. It is, however, a very important type and peculiarly Naval.

I have not yet mentioned the Kite Balloon, which while less interesting technically, is of great importance to the Navy. The Kite Balloon is towed from a ship at an elevation of about 1000 feet. At such elevation, a spotter can control the fire of the ship's guns unless an enemy smoke screen interferes. In that case, the planes must be depended upon. One may ask, why not depend on planes all the time? The answer is: communications. The communications between a plane aloft and the firing ship are by means of radio or some visual signal. At best such signals are difficult to keep clear and when there are many ships firing and many planes aloft, the chances for confusion and interference are very fair. The Kite Balloon observer has a telephone directly to his ship, giving him freedom from interruption and interference.

I have gone into the realm of prophecy a bit in connection with the problem of the rigid airship *vs.* the large flying boat, because this is a real problem now under discussion. A decision cannot be reached from a consideration of the two types as they exist to-day, as each is certain of further development. So far as such development can be forecast, the advantage appears to lie with the rigid airship.

The other Naval types mentioned involve no such fundamental difficulty as a selection of the type best worth developing. The ship's fighting and spotting planes are adaptations of planes brought out during the War. The medium-sized plane for coast patrol is fairly satisfactory as it exists at present. It was perfected during the War for antisubmarine work.

Similarly, the non-rigid airship for convoy duty is well developed, both in the United States and abroad, and no important changes in type are anticipated.

In general, the line to be followed in the design of Naval Aircraft is fairly clear. As the special types needed to meet Naval requirements become more highly specialized, their difference from the aircraft used by an Army will become more marked. Already, a Naval Aviator has come to be regarded as a Naval Officer first, and an aviator second.

DESTRUCTION OF FRENCH COAL MINES AND PLANTS AND THEIR REHABILITATION.*

BY

GEORGE S. RICE.†

Chief Mining Engineer, Bureau of Mines, Department of the Interior.

WHEN the German Imperialists planned their campaign for military and industrial dominion of the world, they did not indulge in the idle dream, that it could be accomplished by purely military means, but carefully studied their successive steps with reference to constant support of their military power by commercial development.

Large resources of coal and iron have led to the commercial greatness of countries possessing them. Agriculture is most important, but is not alone sufficient, as railroads must carry the product to market, and in turn coal and iron are essential to transportation. The ownership of the iron ore alone is not sufficient. Sweden, for example, has splendid iron resources but has had to export its raw product to other countries to be worked up into merchantable iron and steel, and hence it has not reaped the full benefit because it has not possessed coal. On the other hand, take the countries which have been most prosperous commercially in the past hundred years. They are the countries that possess important iron and coking coal resources: Great Britain first, in period of development, Germany next, and

* Presented at a meeting of the Mining and Metallurgical Section held Thursday evening, December 4, 1919.

† The author was a member of a Commission sent by the Secretary of the Interior to France to investigate developments in mining and metallurgy under stress of war conditions, and also to observe the extent and character of the destruction of the collieries and the steel and iron plants, and methods which were being taken to re-establish them. This commission consisted of Dr. F. G. Cottrell, Chief Metallurgist of the Bureau of Mines; Mr. Frank H. Probert, Dean of the University of California Mining School; and Mr. George S. Rice, Chief Mining Engineer of the Bureau. While conducting this investigation Mr. Rice made a trip to the Saar Basin to observe the conditions there. Subsequently Mr. Rice acted as adviser on mining matters to the Representative of the Economic Council in an Interallied conference held at Cologne in April, 1919, and afterward visited mining districts in central and southern France, in Belgium and Great Britain.

then the United States, the latter having by far greater resources of coal and iron than any other country in the world.

IRON RESOURCES OF LORRAINE.

France, prior to the war of 1871, possessed the iron ore of Lorraine (termed minette ore) which in 1871 was not considered

CHART I.

Map of coal and iron basins of Western Europe.

so valuable on account of the high phosphorus content. This prevented its use in steel making, limiting its employment to castings. Nevertheless by the advice of German technicians, Bismarck took from France all the iron deposits then known in Lorraine. Later in 1878, through the invention of Thomas

and Gilchrist of their dephosphorizing process, this ore, although low grade as compared with the hematite ore of the Lake Superior district, became most valuable to Germany's industrial development.

French development companies undertook to trace the ore deposits westward from the boundary of 1871, by deep prospecting bore holes, and established the fact that the minette ores, which are found interbedded with the limestones of the Paris basin outcropping in German Lorraine and Luxemburg and dipping eastward, extended into France. Later it proved there

FIG. 1.

Loos Battlefield on Lens concession. Loos and twin towers of Lens No. 15.

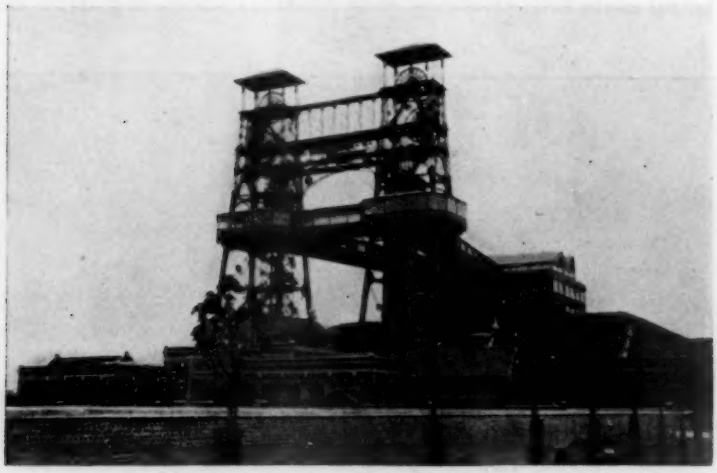
were greater iron ore resources in French Lorraine than in "Lorraine Annex." The basin, as a whole in Germany, France, and Luxemburg, produced 55 million tons of ore in 1913. Although the ore is low grade, carrying on the average only about 33 per cent. iron, it is easily smelted and formed the basis of vast industries in Germany and to a lesser extent in France.

IMPORTANCE OF COAL IN DEVELOPMENT OF IRON.

France, unlike Germany, is somewhat deficient in coal resources, and the natural mining conditions make it difficult to obtain large outputs from the coal basins. Coking coal is the most important factor in the utilization of iron and the shortage of this has in the past tended to restrict the industrial expansion of

France as compared with that of England, Germany, and the United States. Germany having iron ore (until the end of the war) and, what is still more important, having abundant and comparatively cheap coking coal was second only to the United States in its industrial development. In the United States, we have the greatest resources in coal as well as iron, and heretofore our coal, which is shallow and easily mined, has been

FIG. 2.



Twin towers of No. 15 before the war.

very cheaply produced and this has enabled us to make enormous strides commercially.

GERMAN DESIRE TO EXTEND IRON AND COAL POSSESSIONS.

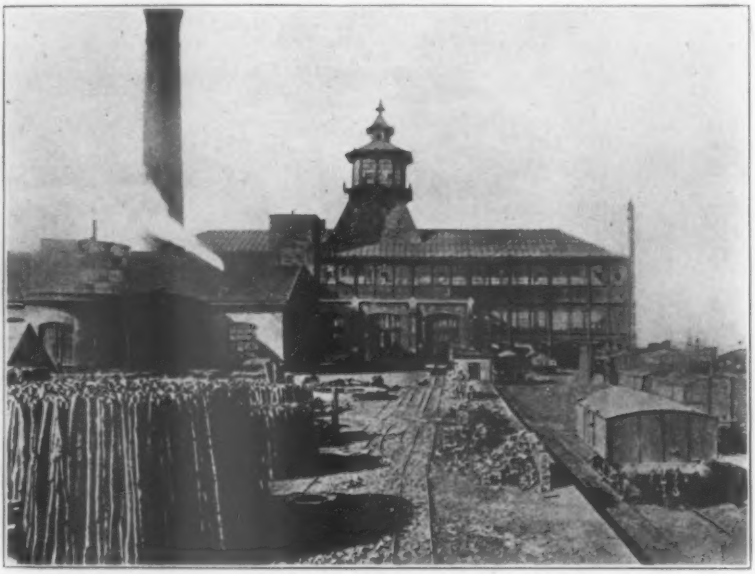
Germany before the war did not produce all of the iron ore which it used. It imported nearly half of its needs,[1] chiefly from France and some from Sweden and Spain. Even before the war, German iron masters hinted that Germany should have the balance of the minette iron ore deposit of Lorraine. After

[1] Germany's production in 1913, including Luxemburg, with which it was tied commercially, was 35,373,000 tons of iron ore. It imported 14,019,000 tons from France, Spain and Sweden, and exported 2,600,000 tons. It used about 47,000,000 tons in 1913.

the war started, while declaiming to the world that they were on the defensive, the German iron masters openly urged the government to make permanent their control of the Briey iron district of French Lorraine which German armies seized when they crossed the border in July, 1914.

While Germany has splendid coking coal resources in its Westphalian field and greater resources in such kind of coal than possessed by any other European countries except England,

FIG. 3.



Lens No. 5 mine before the war.

if the Germans were to hold Belgium, and the north of France, as the Imperialists desired, they would need local coal in those occupied territories. Moreover they wanted coal closer to the seaboard, for bunkering their ships or for exporting, than that produced in Westphalia, which is many miles from their seaports. Mines centering around Dortmund are about 118 miles to Bremen by railroad and 168 miles to Hamburg, whereas the centres of the Belgian field and the Pas-de-Calais coal field of France are only about 50 and 60 miles, respectively, from channel seaports.

The coal of the Belgian field, while in part coking, is mostly

of the steam or semi-anthracite character which would be excellent for bunkering ships. If one examines the map (Chart I) he will notice the great iron basin of France and former German Lorraine is as close to the Westphalian field as to the coal fields of northern France which also contain considerable good coking coal. The Saar coal field is still nearer the iron basin, but as yet only a limited amount of coking coal has been produced—

FIG. 4.

Lens No. 5 mine, destroyed by battle.

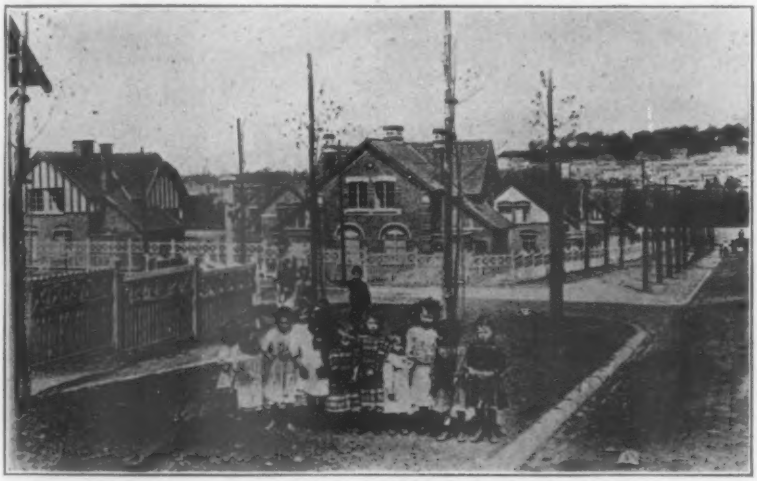
only a few million tons per annum out of a total production of 17,000,000 before the war.

GERMAN DESTRUCTION OF FRENCH AND BELGIAN INDUSTRIES.

For the fullest development of its imperial policy, Germany therefore sought to seize the coal and iron of France and the coal of Belgium. Unexpectedly the war was prolonged and when, following the British drive in the Somme in 1917, the Germans evidently began to doubt their ability to hold Northern France and Belgium, they planned the campaign of industrial destruction. Until that time, the destruction other than the relatively small amount of wreckage from military operations,

had apparently been by unofficial pillage. The campaign then planned was as merciless as it was methodical. All industries in Belgium and France were marked for destruction with two notable exceptions—the iron mines of French Lorraine and the coal mines of Belgium. Both came through practically without injury except some unintentional injuries in the case of the French iron mines through bad mining, that is: in certain mines worked by the Germans, who used prisoners, chiefly Russians, the pillars were robbed, which allowed roof falls to occur, and

FIG. 5.



Liévin miners' village before war.

this resulted in material damage. Other than this the only damage was the taking of copper trolley wires from underground electric roads and substituting iron wire therefor, and some destruction by explosives and burning of miners' villages.

ESCAPE FROM DESTRUCTION OF FRENCH IRON MINES AND BELGIAN COAL MINES.

The reason for the general immunity of the French iron mines is manifest: Germany needed the Briey iron ore. If it could defend this against the owners, as it did until the armistice, so much the better. If not, it would still require to get the iron ore by import for the continuance of its Westphalian iron and steel

industries: The need of Westphalian coal it probably considered its hostage to compel sending minette ore from France.

As concerns the escape from destruction of the coal mines of Belgium, the reason is not altogether clear, but there was nothing to indicate from other matters that it was due to any mercy on the part of the Germans. It was thought that it might have been due to the warning given by President Wilson that such destruction would bring upon them measures of retribution, at

FIG. 6.

Liévin miners' village after bombardment.

a time when they were losing the war. However, this warning did not save the adjacent French collieries whose wrecking proceeded to the day of armistice; on the other hand their escape might have been due to the fact that Belgium produces little coking coal and has no iron ore and hence its iron and steel industry could not be really competitive with the great Westphalian steel and iron industry.

DESTRUCTION OF STEEL AND OTHER INDUSTRIES OF BELGIUM AND FRANCE.

In striking contrast to the immunity of the French iron mines and the Belgian coal mines there was as complete systematic

destruction as possible of all other industries of Northern France and Belgium with the manifest intent to cripple France for years to come. Then if given free rein German factories entirely uninjured by the war and ready to start up, would go ahead and dominate industrially where conquest could not come in a military way. Thus, without the restraints of the Treaty of Peace, Germany would essentially have won the war. Even with the loss of Lorraine Germany would have won industrially and in compara-

FIG. 7.

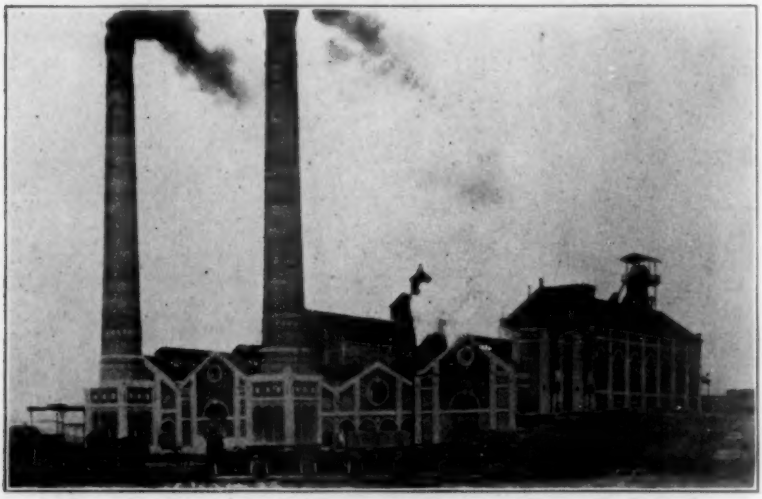
Liévin No. 4 hoisting engine, destroyed by Germans.

tively few years would have been able to strike again, and this is what France feared and still fears. The writer was in Northern France in 1908 and in 1911 and his observation then was that the mass of the French wanted peace almost at any price and were willing to let the losses of 1871 be forgotten.

While the area covered by the German advance did not comprise more than 7 per cent. of the entire territory of France, yet as pointed out by the late Colonel Edouard de Billy, head of the French High Commission, these invaded districts were the most developed industrially. From them came 30 per cent. of the industrial output of the country; 90 per cent. of the iron

ore; 83 per cent. of the pig iron; 75 per cent. of the steel; 70 per cent. of the coal; 94 per cent. of the combed wool; 90 per cent. of the flax; and 65 per cent. of the sugar. They produced four-fifths of the woolen wear and included 80 per cent. of the weaving industry. The Germans robbed the plants of their machinery, and structural steel and iron were cut up and taken to Germany for reworking. The mines were flooded, surface plants dynamited, workmen's buildings and farm buildings destroyed and agricultural machinery destroyed or carried away.

FIG. 8.



Liévin No. 3 mine before war.

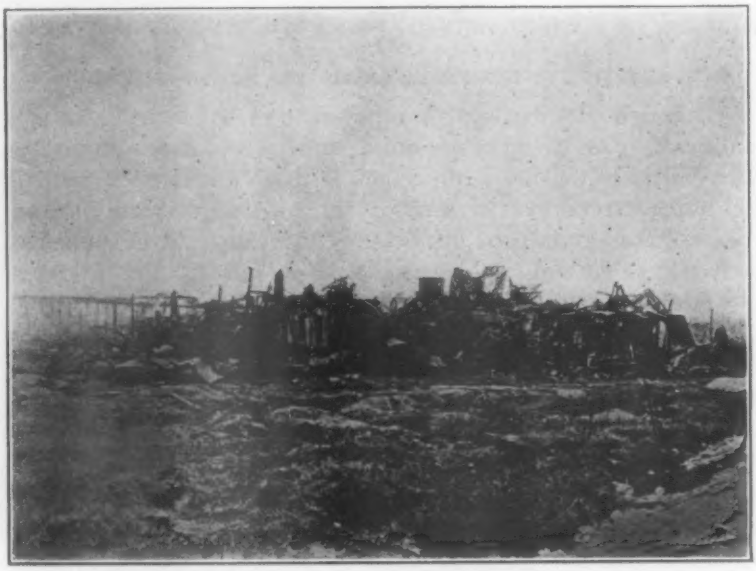
It is true that some of the destruction of the mines was due to battle and from military needs, but this kind of destruction probably did not represent more than a few per cent. of the total destruction. The steel plants and the industrial plants were in most cases miles behind the lines, but their wreckage was just as complete in effect, though not so spectacular, as that in No Man's land.

DESOLATION CAUSED BY GERMANS IN FRANCE.

The attempt to make the invaded provinces of Northern France a desolate region was very striking, especially in contrast with the treatment of Belgium after the first savageries. Probably it was due to the cold-blooded calculation that Belgium was

not a serious industrial competitor, whereas France was. Belgium, outside of the limited battle area and destroyed blocks or isolated buildings in some of the cities, as at Liege and Louvain, where the Germans wished to strike terror to the hearts of the inhabitants, was physically damaged to small degree. The repression of the people by harsh methods made life by no means easy, but the conditions were in striking contrast to Northern France last winter, where one might travel for miles without see-

FIG. 9.



Liévin No. 3 mine, destroyed by battle.

ing a living being, only demolished or uninhabitable villages and cities, often mere piles of brick and stone. Even in the larger cities of the coal fields outside of the battle area, as in Valenciennes and Douai, blocks of houses had been destroyed without apparent reason and thousands of humble dwellings burned or blasted with dynamite. The pillage extended to banks and private property. For example, the writer visited a bank at Douai in Northern France. The president showed to him the safety deposit vaults under the bank. All the doors of the security boxes and safes had been neatly cut out by an oxyacetylene

torch. Not only had all articles of intrinsic value been removed but even the papers had been taken and sent to Berlin, nominally, for safe keeping. One can well imagine the difficulties of straightening out the titles to property in the invaded provinces for years to come.

The people in these French provinces suffered more from lack of food than those in Belgium. The writer was told the Germans prevented Hoover's men from distributing the food in France, insisting that it be done through the German military authorities, which of course meant the inhabitants were robbed of their full rations. They looked anemic as compared with the Belgians.

DESCRIPTION OF THE PAS-DE-CALAIS AND NORD COAL BASIN.

Although France has 50 separate and somewhat scattered coal fields, most of them are quite small and of local importance only. By far the most important is the Valenciennes basin in the northeast corner of France and this is divided into the Pas-de-Calais and Nord districts. Often the field is spoken of as the Pas-de-Calais field and since the war is usually known to Americans as the Lens field on account of the terrific struggle around the city of Lens.

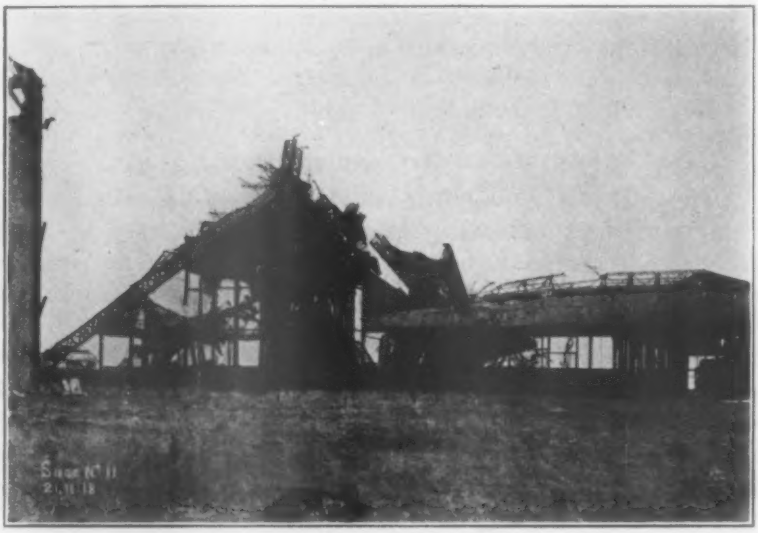
The basin is a continuation of a long narrow geologic trough lying east and west. Easterly it extends through the south part of Belgium and the following well-known industrial centres are found successively in going east along its course: Mons, Charleroi, Namur, and Liege; thence it passes into Germany at Aix Le Chappelle. Going westerly from the French-Belgian border, it extends in France through Valenciennes, Douai, Courrières and Lens and then northwesterly through Béthune, all names being made famous by the war. A narrow off-shoot of the coal field extends westwardly through Bruay and Marles and thence to Fléchinelle. It was this extension of the field that was not invaded, and by intensive working the French succeeded in greatly increasing the output of the collieries in this part of the extension in spite of long-range bombardment.

GEOLOGIC AND MINING CONDITIONS

The coal is of Carboniferous age and in character ranges from long-flame bituminous coal to semi-anthracite with a fair portion of coking coal. Where all the beds are present there

are 90 coal beds with an aggregate thickness of 250 feet, but generally not over two-thirds of these beds are present at any one point and many of them are not of workable thickness, the total thickness of the workable coal usually being not over 150 feet. Most of the beds are less than 3 feet in thickness. In some instances two beds unite giving locally a thickness of from 9 to 12 feet. There may also be a local thickening of the bed due to the folding back of a seam. At Lens where the conditions

FIG. 10.



Béthune No. 11 mine, destroyed by long range bombardment by Germans.

are typical, the total coal thickness of the measures is 4300 feet with 51 workable beds present containing 154 feet of coal.

The geologic structure is very complicated; subsequent to formation of the coal measures there was a great geologic thrust from south to north crumpling up the measures and producing sharp overturned folds and overthrust faults as well as cross faulting. Rocks of Devonian age have been thrust over the coal measures on the south side of the basin. The general strike of the rocks, subject to many local changes, is east and west and the normal dips which are usually steep, 20 to 40 degrees, are to the south.

After the upturned measures had been planed off by long continued erosion, they sank below sea level and chalk and marls have been deposited over the upturned edges. Then the strata lifted and these chalks and marls were slightly raised above the sea level. The surface over the basin is generally flat, rising to the south in low hills or ridges, one of the most prominent ridges south of Lens being the famous Vimy Ridge which commands a wide view over the basin. Here military mining was extensively done by the Germans and British, and the British thrust back the Germans in 1917. The superficial dimensions of the basin are 62 miles in length from the Belgian border and in width varying from 2 miles up to 10 miles at Lens. The entire superficial area covers about 405 square miles. This does not include the Belgian part of the basin.

KINDS OF COAL AND PRODUCTION

There are wide differences in the composition of the coals, the variation in the volatile combustible content ranging from 7 to 40 per cent. High volatile coal is found in the outcrop coals along the north margin, the volatile matter ratio decreasing toward the south margin, where the coals lie deeper.

Of the 26 million tons (metric) produced in 1911 there were 4 million tons or 15 per cent. of semi-anthracite, 3,900,000 tons or 15 per cent. non-coking or semi-bituminous; 11,200,000 tons or 43 per cent. of coking and gas coal; and 6,900,000 tons or 27 per cent. volatile or splint coal. In 1913 the total production was 28 million tons.

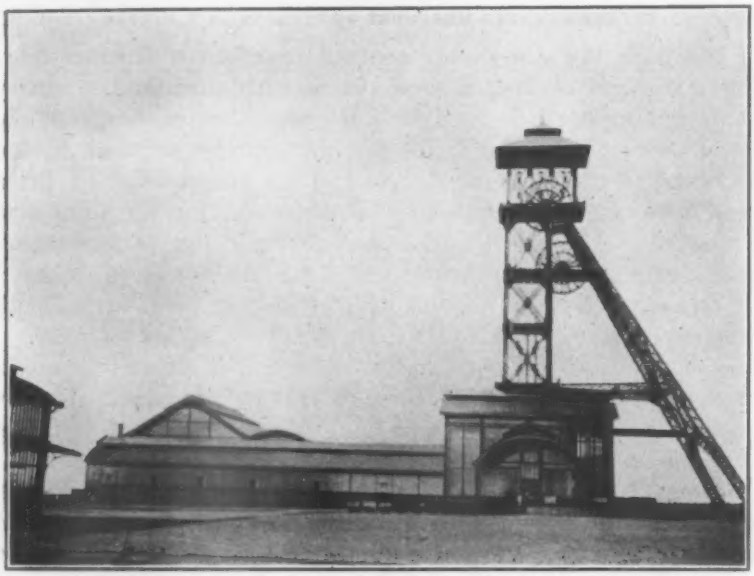
The coal is of good quality but is generally friable in character. It is low in ash after the careful cleaning given it, which is done by numerous pickers and by washing the small coal. The moisture content is low. The steam coal, when briquetted, makes a splendid steamship fuel. All coke is made in by-product ovens; 2,873,000 tons of by-product coke was produced in 1913 out of the total production for France of 3,667,000 tons.

There were 50 extraction pits or shafts in the Nord district and 100 in the Pas-de-Calais besides numerous auxiliary and ventilating shafts. An average of 7 to 8 beds was worked from each pit. The average depth of extraction, that is, the average depth of coal hoisting, was about 1200 feet, and the deepest hoisting from any pit was 3300 feet.

MINING PLANTS AND DEVELOPMENT

The equipment and development of the mines was very high class in character. It may be said that there were no finer mining plants in the world than those of Northern France. Steel pit head frames, architecturally attractive; substantial and fireproof tipple and screening buildings; splendid hoisting engines, chiefly electric in the largest plants; well-designed fans which

FIG. 10a.



Béthune mine No. 11 before the war.

were always in duplicate; and other power and labor-saving equipment of the best type.

Those mining concessions possessing coking coal had by-product oven plants and central power stations using the surplus gas and supplying the respective concession with electric power for the different mines on the concession. In the case of the Lens collieries, which had the largest production of the basin, the central power station furnished electric power for canals and other public utilities for a distance of 100 miles towards Paris.

As regards housing, the miners' dwellings in the ancient towns, although constructed of brick and stone, did not have

modern improvements, but the more recently constructed dwellings and other buildings in the mining villages, all now destroyed, were made very attractive, and much attention was given to sanitation and sociologic features.

Practically no wood was used in the construction of colliery buildings; steel and brick were generally used for framework and walls, and the roof coverings were of tile and glass supported by steel girders or arches.

WATER-BEARING MEASURES PENETRATED BY SHAFTS.

As the coal measures are generally overlain with water-bearing marls and chalks, in some places with quicksand, ordinary shaft-sinking methods were often impracticable on account of the great flow of water, and many of the shafts were sunk by the freezing process. In more recent years the method of prior cement injection through bore holes surrounding the shaft was employed. The shafts are lined through the water-bearing strata with iron curbing rings and through the rock with brick, or concrete. Usually a single colliery has only two shafts, both equipped for hoisting, the air shaft usually being used for lowering supplies and hoisting and lowering men. Sometimes both upcast and downcast shafts were used in hoisting coal. Underground connections were made with other collieries of the same concession and since the Courrières disaster (1906) and M. Taffanel's coal-dust explosibility investigations (1907–1914), such connections had been especially designed with explosion stopping arrangement and equipped with special "shale-dust barrier" devices. Some of the shafts hoisted coal from several levels, but usually the hoisting was done in balance from one landing level, the coal being assembled from levels below or above by hoisting or lowering in underground shafts.

MINING METHODS.

Owing to the disturbed conditions of the coal beds, the underground method of development is entirely different from that which prevails in the United States, the main levels or gangways are driven across the strata, that is, at right angles to the strike of the coal beds, and when a coal bed is cut, it is blocked out by "entries" and "slopes" or "raises" in the bed. Owing to the large amount of extensive cross-cut tunnelling and uncer-

tainty regarding local changes in the beds, the Government laws permit the driving of long advance or exploratory tunnels singly, the ventilation being obtained by use of large metal pipes in connection with a suction fan placed at the mouth of the heading and operated by a small compressed-air engine, electric motors not being permissible on account of the danger of igniting fire damp. The ventilating pipe is made of rivetted galvanized iron sheets 12 to 20 inches in diameter. This method of development, in comparison with double entries required by the state laws of this

FIG. 10b.

Béthune No. 11 safety lamp house before the war.

country, appears to be safe, as under the French law a working coal face cannot be developed from a single heading; hence no pockets are made in which fire damp might accumulate, but development must await connections being made with the next level above in order to obtain a circuit of air. A further excellent safety requirement is that ventilation must always be ascensional, that is, the intake must enter on the lower level.

LONGWALL METHOD AND PACKING.

The longwall system is used in working the coal, the faces, usually in steps, the lowest being in advance, are parallel with the dip. The "goaf" or excavated space must be entirely filled

and well packed with rock and refuse. As the roof is generally a weak shale, extensive timbering is required and this is done with unusual care in the north of France, a forepoling system of support at the face being employed. The filling and the pack-wall material is rock obtained in driving the cross-cut tunnels and from brushing in the gangways. As there is usually a surplus of rock obtained in mining the thin beds this surplus is taken into the workings of thicker beds. Where there is insufficient rock or debris for filling and packing some must be sent from the surface. At a number of collieries the hydraulic or flushing system was being employed, using washery refuse and cinders. In later years some sand for hydraulic filling had been brought from the seashore.

Where there is local thickening of the coal, special mining methods are employed such as the use of square sets and a back filling method similar to that used in metal mines. The writer saw this method being used before the war in one of the Courrières collieries where the coal, due to a fold, is locally 40 feet thick.

The main entries of the levels are closely timbered and in the permanent main haulage-ways brick and concrete archings are extensively used. Miles of light reinforced concerete lining had been constructed in Béthune No. 11, one of the destroyed collieries.

GAS AND DUST PRECAUTIONS.

As might be expected in deep deformed coal measures, the mines are generally gaseous and safety lamps are required. Hand storage-battery electric lamps were used to some extent. On the whole, except in some of the deeper "pits," the mines are not as gaseous as those in Belgium, and ventilation methods are especially good. The French companies were perhaps the first to adopt, years ago, the modern method of systematic daily analysis of the returns of airways, in order to obtain definite information for the control of ventilation.

Until the great Courrières disaster of 1906 in which 1100 men were killed, the French engineers because of laboratory tests held the opinion that coal dust in itself would not propagate an explosion, but this disaster changed their point of view; following it extensive experiments were begun under an investigative bureau established by the Central Committee of Collieries of France.[2] The

[2] Comité Central des Houillères de France.

experiment station was located at Liévin in the Pas-des-Calais, with Col. J. Taffanel, one of the Government mining engineers, in charge. The coal dust explosibility investigations conducted by Colonel Taffanel were basic in their findings and were of the utmost value to the author in carrying on parallel testings at the Experimental Mine of the Bureau of Mines, at Bruceton, Pa. The Liévin experimental station was on the battle line early in the war and was totally destroyed.

FIG. 11.

Béthune No. 8 mine destroyed by battle. Alternately in possession of British and Germans.

TIMBERING AND INSPECTION.

Great precations were taken by the French in mining, especially as regards timbering. Except for the year of the Courrières disaster their record rivalled that of Belgium for the least number of lives lost per thousand employed underground, the yearly rate being about one per thousand employed. This is nearly fifty per cent. less than obtained in either Germany or Great Britian and one-third the rate of this country. Such a low death rate from accidents was the result of the operators not sparing expense and the governmental inspection being rigid. The inspection service is in the hands of highly trained mining engineers assisted by "miners' inspectors."

COMPARISON OF PRODUCTION PER MAN, FRANCE AND AMERICA.

The production per man in France, as in Germany and Great Britain, is low compared to that in the United States, but this is not, as sometimes is assumed, because the workmen in this country are better than those of France but is chiefly due to machine mining. In this country the bituminous coal beds as worked average thicker, lie level, and the conditions are regular, making the extensive use of mining machines both possible and profitable.

FIG. 12.

Béthune No. 8 cratered shaft, blasted by Germans.

In France the pitching and irregular character of the coal beds and the poor roof prevent the extensive use of undercutting machinery and in most cases it is not needed as the coal is soft or spalls off under heavy pressures. However, mechanically shaken loading chutes are used at the longwall faces where the grade is too flat for the coal to run unaided. Secondly, the requirement that thin coal as well as thick coal must be mined, necessitates a large amount of dead work. The third important factor is the requirement that the workings shall be packed to prevent subsidence and this may frequently be very costly, as the packing material generally has to be sent to the mining face and it may have to be quarried or excavated on the surface. Fourth, there are no

FIG. 12a.

Another view of the cratered shaft of Béthune No. 8 mine.

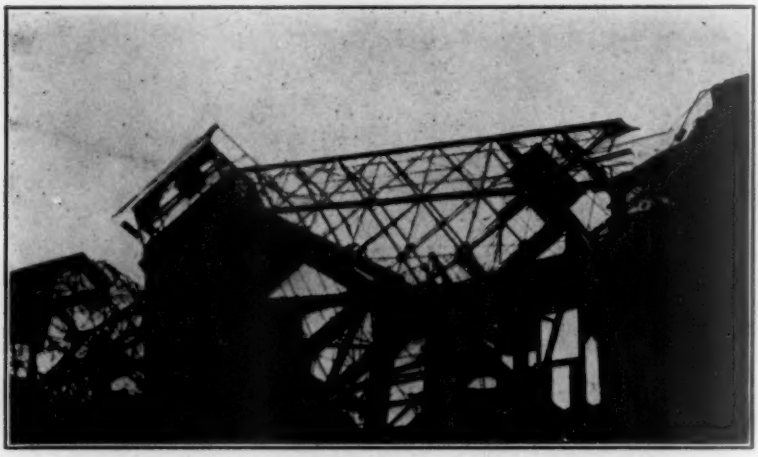
chances taken in questions of safety, especially timbering. In this country, although the mine roofs are almost always stronger, our accident rate from falls is vastly greater than theirs. Falls of rock and coal represent 40 per cent. of our coal mine accidents.

MINER'S PRODUCTION AND EARNINGS.

The average production for an underground employee per annum in the Pas-de-Calais field was 300 tons (metric), and per working day about 1.1 tons.

Prior to the war the miners working at the face averaged about 7 francs or $1.40 pre-war exchange, per shift of eight hours. The boys, drivers and helpers were paid 5 to 6 francs ($1.00 to $1.20); all inside labor averaged $1.20 per day. The age limit of the boys employed underground was 13 years.

FIG. 12b.



Overturned head frame of Courrières No. 6 mine. Systematic destruction.

MINE OUTPUTS, SELLING PRICE AND COSTS.

The colliery which had the largest output of coal and coke of the basin was the Lens Company which produced about 4,000,000 tons (metric) annually. Next in point of output were Anzin and Courrières, each of which produced over 3,000,000 tons. Then followed Béthune and Liévin producing about 2,000,000 tons each. The underground labor cost in the basin was reported to average about $1.10 per ton. Including surface labor the total labor cost of coal delivered on railway cars was about $1.40 per ton. The entire operating cost, including supplies, superintendence, and other items, of placing coal on cars was from $2.20 to $2.50 per ton. The average selling price of the coal at the mines preceding the war was 16 francs, or about $3 per ton. The gross profit,

FIG. 13.

Courrières No. 9 cratered shaft, destroyed by Germans. Mine far behind battle line.

not including the income tax, was from 60 cents to $1 per ton. This profit was on the coal and did not include coking and by-products profits.

The number of work days per year averaged 300, and the average production per hoisting shaft per annum was about 75,000 tons.

The mining companies did not own the coal but received concessions from the Government, paying a nominal rental of 10 cents per hectare (2.471 acres). The principal taxes are collected from a percentage of the net earnings, and prior to the war the tax was 6 per cent. of the earnings available for dividends.

POST-WAR LABOR WAGES.

As in this country, during and since the war the wages paid labor had doubled or trebled. Last April the Courrières Company, which was then one of the companies most actively engaged in cleaning up, was paying 14 francs per day to ordinary workmen, one franc additional being allowed to men with a family, and 17 francs ($3.66 pre-war exchange) for skilled workmen.

In the Bruay colliery to the west of the battle line, which was operated intensively during the war, the miners were earning in April from 15 to 18 francs per day, general underground laborers being paid 12 to 14 francs.

PRODUCING MINES IN PAS-DE-CALAIS DISTRICT

There were only one-half a dozen collieries left to the French to produce coal at the west end of the coal basin. Their production, by concentrating miners in them, had been raised from 2400 to about 3800 tons per day. In 1915 the production of this area was 7,382,000 tons. In 1916 it had been raised to 8,195,000 tons and in 1917 to 11,450,000 tons. In 1918 some additional mines in the vicinity of Bethune were lost by the advance of the German lines in their spring drive and the total output for this end of the field was probably a little less than in 1917.

Following the armistice the output lowered 15 to 20 per cent. on account of the miners leaving for their old homes and the collieries dropping from 3 eight-hour shifts per day to 2 shifts of eight hours.

HISTORICAL REVIEW OF THE DESTRUCTION OF THE COLLIERIES

Through the kindness of the Central Committee of the Collieries of France (Comité Central des Houillères de France) [3] I received data giving chronologically the progress and character

[3] A permanent organization of all French collieries for coöperative investigations in the coal industry. Before the war it maintained a safety investigative bureau at Liévan in the Pas-de-Calais, of which Col. J. Taffanel was director.

of the destruction of the collieries; from that and from data secured during my visit the following story was written November 29, 1919.

The invasion of the field in August, 1914, by the Germans began immediately after the retreat of the British from Mons, southward toward Paris. Mons is in the Belgian coal field about 10 kilometres (six miles) from the boundary between Belgium and France. On the 24th of August the concessions in the vicinity of Valenciennes had been occupied. By October 1, the invasion

FIG. 14.

Boilers at Courrières No. 9 with holes in domes, holes also being blasted in bottoms of boilers.

had spread to the concessions in the vicinity of Douai, and by October 6, Lens and Liévin had been occupied.

During the first invasion, until the stabilization of the fronts at the end of October, the destruction was carried on under plea of military precaution against the utilization of the pits near the firing line by the allied armies. It consisted of the destroyal in some of the mines of the means of extraction and of communication between the bottom and the surface, such as cutting the cables and throwing cages and buckets to the bottom of the shafts.

During that period stores, provisions, timbers, and locomotives were seized, and there occurred a certain amount of pillage and unauthorized destruction on the part of the rank and file.

At that time there was no real excuse for the destruction as there was no fighting except for a few hours in the streets of Billy-Montigny and Drocourt. At Courrières and Lens, in the first days of the occupation, the German military authorities forbade all work of maintaining the bottom or the pumping of water. Of course no Frenchmen of military age remained in the district, all having been mobilized at the outbreak of the war, but old men, women, and children largely remained as the invasion was too rapid for the general escape.

STABILIZATION OF BATTLE LINES.

Upon the stabilization of the lines the trench warfare began and at the end of October the front line of the trenches passed through the concessions of Douvrin, Béthune, and Liévin. The Lens concession was in the range of the allied heavy artillery. With the exception of these concessions, which were exposed to the bombardment of both sides, during the second period which lasted until the conquest of Vimy Ridge by the English in 1917, the destruction by damage resulting from the operations of war was comparatively small. Meantime during this period there was continued removal of the apparatus, stores, and provisions without requisition orders, or in some cases with orders for quantities much less than were taken away, and at low values.

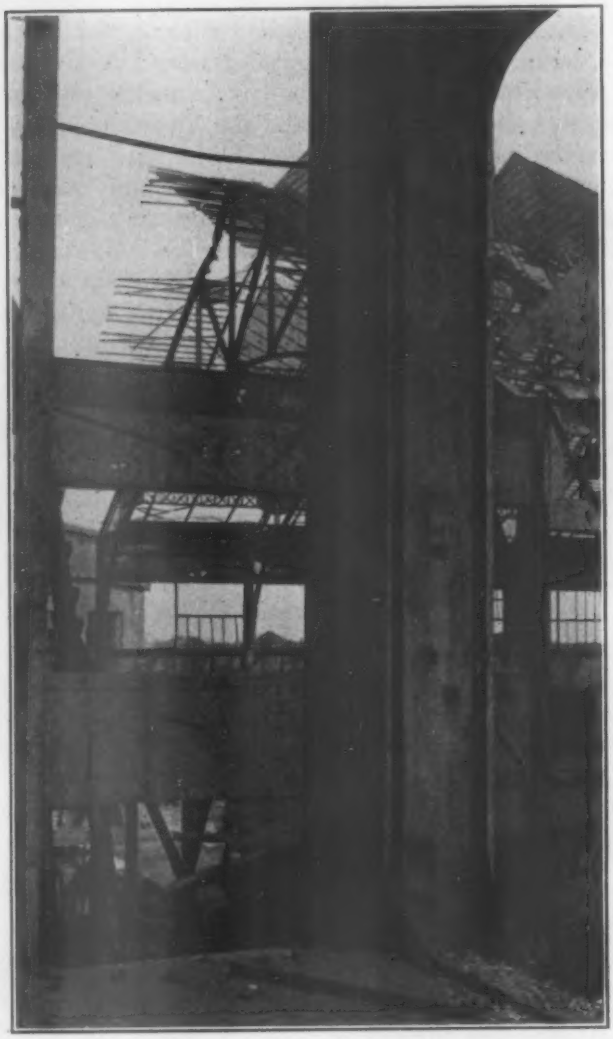
At Courrières, for example, mine wood was taken to the amount of 4 million francs value at that date, and 1600 wagons were removed for which the enemy gave requisition for 100 wagons.

At Carvin, which lay far behind the firing line, wagons and electric wires were removed and there began a general seizure of copper from all kinds of machinery which were destroyed in obtaining the copper. The German military regulations forbade the companies to have their workhouses and pits examined at night. It was during the night that most of these removals were effected, so that the Germans would be able to refuse requisition orders.

TREATMENT OF LENS COLLIERIES. FIRST PERIOD OF DESTRUCTION.

For the Lens collieries special treatment was reserved. Up to September 25, 1915, these mines had suffered comparatively little by the enemy occupation except for repair work underground, the usual daily examination of the pits being prevented.

FIG. 15.



Courrières No. 21 new unfurnished plant partly demolished, showing holes made in post for blasting. Sign marked 12½ Kg. (weight of explosive to be used).

At that time a big French-English attack furnished the Germans with pretexts for the severest measures. The British Army had taken the town of Loos and pit 15 of the Lens mine. This was one of the splendid new mines of the company, and its high head frames occupied a commanding position. The German command pretended to see the possibility of a means of communication between the English lines and the French population, who remained behind the enemy lines. Objections were raised by mine managements that there was no possibility of such communication as the mines had not been ventilated for nine months and moreover the shafts of the mines had been guarded by military guard during this period and nobody had entered. M. Reumaux, the managing director, suggested to the German military authorities that they completely seal at the bottom the outlets from one mine to the other and hermetically seal the shafts, leaving only small openings for escape of firedamp.

FLOODING MINES.

These proposals were submitted to a mission of engineers from the mines of Westphalia who, in spite of the obvious military security of the proposed measures, pronounced them insufficient; this of course was a mere subterfuge to give excuse for the fearful destruction. It was then ordered that the mines be inundated by blowing up the shaft lining and this was done in Lens pits 5 and 11. The inundation spread not only through the pits of the Lens concession but also through those of neighboring concessions at Meurchin, Liévin, Carvin, and Drocourt, rendering these workings useless for many years. This meant the loss to France for five years at least of 8 million tons or one-fifth of the national production at this time.

SECOND PERIOD OF DESTRUCTION. SYSTEMATIC WRECKING BEGUN.

Apparently in 1917 the Germans foresaw they must ultimately retreat, and began systematic destruction of surface installations heretofore untouched. Gangs of pioneers began to break up the surface plants and destruction of the steel headframes was prepared in advance to be executed at each pit as the Germans withdrew.

After the conquest in April, 1917, of Vimy Ridge, which lies to the south of Lens and overlooks the low-lying coal field,

resulted in placing the Lens concession in the firing line, there was fighting in and among the workmen's dwellings in Lens and surrounding villages; also part of the Courrières and Drocourt concessions came in the allied bombardment zone. Courrières collieries which had been in operation under control of the Germans were stopped and the neighboring population was evacuated. On April 13, the village of Henin-Lietard (Dourges)

FIG. 16.

Canal loading station of Béthune mines. This and barges destroyed in battle.

was also evacuated. The workmen's cities in the vicinity and surface installations at Drocourt pits 4 and 5 were destroyed by the bombardment.

THIRD PERIOD OF DESTRUCTION. COURRIÈRES MINES FLOODED.

In spite of advance of the front line of the British in 1917, the greater part of the Nord Basin to the East was still out of reach of the bombardment and consequently free from damage of military operations. Yet at this time everything was taken from Courrières mines and villages—even to hand tools and furniture, without military need. At Courrières 160 steam boilers were wrecked and, at Dourges, by means of explosives, the

machinery, trestles, etc., were destroyed. Then followed the blowing up of the lining of Courrières pit No. 9 and the flooding of the mines of this concession by water flowing from the quicksands and chalks. To hasten this process, the Germans ditched in surface ponds and swamps. The chief engineer of the Courrières Company informed the writer in April, 1919, that from sounding in some of the shafts, the company estimated there were 20 million cubic metres of water in its group of mines. The bulk of this water would probably have to be pumped from the depth of 1500 feet at least. Destruction during this period meant the loss of 4 million tons annual output to France.

In the spring of 1918 came the last German drive and while the British line held around Vimy Ridge and Lens, it was forced back into the vicinity of La Bassee and approached closely to Béthune, thus bringing the remaining Béthune mines under direct fire, and the mines at Bruay under long-range fire of the Germans. The last named was among the few important collieries left in working condition in the Pas-de-Calais field. However, while the long distance bombardment of Bruay did some damage it did not prevent continued operation of the mines, although there were grave difficulties in running trains and at one time this could only be done at night.

FOURTH PERIOD OF DESTRUCTION. FINAL WRECKAGE BEFORE GERMAN RETREAT.

The fourth and last period began with the final retreat of the Germans in September and extended to the date of the armistice, November 11, 1918. This retreat, which finally forced them back across the frontier beyond Mons in Belgium, was so rapid that little battle damage occurred after the opening phase which brought the mines in the vicinity of Douai into the firing line, but even at these mines the devastation was not so much from bombardment as from systematically planned destruction. This destruction all the way to the Belgian line had to be carried out in a very short time. It would seem that military fighting ought to have monopolized every effort of the Germans, yet during this final period the greatest damage was wrought in the shortest time by the enemy. The collieries that remained intact until the month of September, 1918, represented an annual extraction of nearly 8 million tons, or more than one-third of the total

FIG. 16a.

Canal loading station of Lens Collieries at Pont-à-Vendin, before the war.

production of the collieries invaded. For example, at the Aniche colliery on October 1, the extraction having been stopped the day before, three gangs of 75 pioneers began the devastation. On October 7 it was nearly completed. Eighteen mine shafts, including washeries, coke oven, railways, and bridges were destroyed.

Installations at the bottoms of the shafts were also destroyed, but to what extent was not known in May, 1919. Successively every mining plant was destroyed as the Germans retreated back to Belgium.

Hindenberg's order of October 15, forbidding destruction without military utility, issued as a result of the ultimatum of the United States Government, did not stop the systematic devastation even where no military needs existed. The Aniche and Anzin destruction was not completed until October 18 and Crispin, adjacent to the Belgian boundary, remained intact until October 28, when a battalion of pioneers arrived and proceeded to destroy totally the machinery and works. The German Captain (Edelmann) charged with the supervision of the mines, struck with the uselessness of the destruction he had received the order to carry out and probably uneasy as to his personal responsibility because of the American ultimatum, demanded and obtained from Ludendorff himself, the written order to continue the destruction.

SUMMARY OF DESTRUCTION

The Central Committee of France has set forth striking figures, which may be summarized as follows: The destruction of 220 pits and shafts belonging to 20 operating companies which were rendered unstable for several years; all surface installations were destroyed in detail. An annual production of more than 20,000,000 tons, or 50 per cent. of the production of all France in 1913, has been, temporarily at least, lost to the country. Unemployment was forced on 100,000 people and they and their families were reduced to extreme poverty.

Finally the Central Committee estimates that the material damage amounted to at least 2,000,000,000 francs in value (on a pre-war basis of exchange $400,000,000). This does not include the loss to France of at least 100,000,000 tons of coal production, for a period of 5 years, counting only the period of the war and the armistice, besides which there would be the loss of valuable by-products. So France to-day pays heavily for coal that it lost through the German occupation and destruction.

RECONSTRUCTION. TERMS OF TREATY OF PEACE.

Based on the terms of the Treaty of Peace the official French findings for the reconstruction of the mines evidently are that

it will take two to five years to get all the collieries in condition to hoist coal and at least ten years to get back the normal output of the basin. These terms are:

"Germany undertakes to deliver to France 7,000,000 tons of coal per year for ten years. In addition, Germany undertakes to deliver to France annually for a period not exceeding ten years an amount of coal equal to the difference between the annual production before the war of the coal mines of the Nord and Pas-de-Calais, destroyed as a result of the war, and the production of the mines of the same area during the years in question;

FIG. 17.

Canal at Pont-à-Vendin, near Lens coke oven plant, showing destruction by battle.

such delivery not to exceed 20,000,000 tons in any one year of the first five years, and 8,000,000 tons in any one year of the succeeding five years."

"The Allied and associated Governments interested may demand the delivery in place of coal of metallurgical coke in the proportion of three tons of coke to four tons of coal."

In the foregoing requirement it must be understood that the coal is not being furnished free by Germany but will be a profitable commercial transaction for the Westphalian operators as the price to be paid for the coal delivered at the French boundary will be the "German pit head price to German nationals" plus the freight to the boundary, or to the German seaport, "provided

the pit head price does not exceed the pit head price for British coals for export."

SAAR MINES TRANSFERRED TO FRANCE.

In this connection it may be well to clear up an erroneous impression that the Saar region has been finally turned over to France. Its mines have been, but not the sovereignty of the territory. The conditions imposed by the Treaty of Peace are these:

"As compensation for the destruction of the collieries in the north of France and as part payment towards the total reparation due from Germany for the damages resulting from the war, Germany cedes to France in full and absolute possession, with exclusive rights of exploitation, * * * the coal mines situated in the Saar basin * * *."

This includes undeveloped deposits whether belonging formerly to the Prussian State, the Bavarian State or private interests. The chief properties were the so-called Prussian fiscal mines, there being only a few privately owned mines, the owners of which will have to look to the German government for compensation. The fiscal mines of Prussia were acquired by that country in 1815 through the Vienna treaty of peace. In 1913 they produced 12,223,000 tons of coal. Several Bavarian mines included in the transfer produced, in 1913, 810,546 tons. The foregoing does not include the Lorraine portion of the Saar Valley field which was returned to France, the production of which in 1913 was 3,816,815 tons.

SAAR DISTRICT, PLEBISCITE.

While the ownership of the mines of the Prussian Saar basin thus passed to France permanently, the inhabitants of the Saar territory after a period of 15 years, are to determine by vote whether they wish:

(*a*) Maintenance of the regime established by the present Treaty.

(*b*) Union with France.

(*c*) Union with Germany.

CONSIDERATIONS IN RECONSTRUCTION IN FRENCH MINES.

Although to those not familiar with the conditions, the time for reconstruction indicated in the Treaty—10 years for complete

reconstruction and recovery of output—seems unnecessarily long, yet after one has traveled through the basin and reviewed the situation, taking into account the renewal of transportation facilities, the absence of adequate housing, the scarcity of building materials of all kinds, the requirement of fireproof and permanent construction of mine buildings, and has observed the frightful tangle of concrete, debris and twisted steel, he is prepared to understand the stupendous nature of the task. Besides

FIG. 18.

Aniche-Nord mine, systematically destroyed by Germans.

these physical difficulties, France to obtain maximum progress will have to purchase machinery and supplies from abroad which entails the serious problem of financing, with the balance of trade so much against her, instead of proceeding more slowly and constructing in France the needed machinery.

When the writer visited the mining district last April, the preliminary recovery work had been going on very slowly on account of the lack of transportation facilities. Reconstruction itself had not started at that time, only the main railway from Paris to Brussels had just been hastily reconstructed with temporary bridges; the branch lines still remained wrecked even

to the road bed, and all the bridges over the numerous canals and streams were down. The preliminary rehabilitation of the district is more difficult than the preliminary development of a new field because the tangled debris of steel, bricks and stone is in the way.

RECOVERING THE SHAFTS.

It had been suggested by those not acquainted with mining conditions underground that the old shafts had better be abandoned and new shafts sunk, but this would not be practicable until the shafts with blasted linings which permit the water to run freely into the mines have been repaired to exclude the water. When this most difficult task has been accomplished it would be advantageous in point of time and expense to accomplish the easier task of recovering the shafts through the 1000 to 2000 or more feet of rock strata to the former working levels and then obtain the benefit of all the expensive underground tunnelling and development. Although it is reported some demolition had been done underground, it was not thought likely by the French engineers that this damage was irreparable. Water has doubtless done great damage at the faces and in timbered sections, but it is thought the greater part of the extensive development is not badly injured.

No statements could be obtained from the local engineers as to the proposed method of engineering procedure, as they awaited the decision of an official board of engineers, but it seemed to the writer that the only way would be to boldly get at the work of recovering the cratered shafts by putting in new linings through the water-bearing ground, and that this might best be started by using through the débris large drop shafts, 25 to 30 feet in diameter, planned to telescope over the old lining where intact, using compressed air locks where the water pressure was not too great and where it was either the cementation process or the freezing process. There would of course have to be many special methods employed to meet the particular conditions. The broken steel and iron head-frames in the shaft craters will undoubtedly prove serious obstacles. An extensive use of oxyacetylene or oxyhydrogen torches for cutting up the twisted steel will be required.

HOUSING PROBLEMS.

One of the grave problems is the providing of dwelling places for the workers. Last April there had been many drifting back, pathetic little parties on foot, pushing or dragging their pitiful household remnants; more than the Government could properly care for. These had set up housekeeping in corners of ruins or in cellars. Providing a water supply for domestic use is another

FIG. 19.

Interior of power-house of Aniche-Nord, showing systematic destruction.

of the problems. The Government found it difficult last winter and spring to supply the people with even a small allotment of provisions on account of the lack of railroad facilities, and many army trucks had to be employed.

PURCHASE AND ALLOCATION OF MINE SUPPLIES.

In restoring the mines, as already stated, there was difficulty in obtaining machinery and supplies. The Government found it necessary in conjunction with the Central Committee of Collieries of France to establish a centralized office for the purchase of all materials needed in the reconstruction of destroyed indus-

tries, and this organization (Comptoir central d'achats industriel pour les regions envahies), which later came under the ministry of direct reconstruction (Reconstruction industrielle), purchases all materials and equipment and allocates them to the different industries and mines, but each mining company has been permitted to use its own discretion in the execution of the work of rehabilitation.

There has been reluctance on the part of the Government to permit purchase of machinery outside of France on two accounts; (1) rate of exchange, and (2) desire to avoid increasing the debt of France to other countries. However, it is expected that German mining machinery may be furnished as part of the reparation due from Germany. Many of the large electric hoisting engines and smaller equipment which had been destroyed were of German manufacture. While the French manufacturing establishments are able to turn out almost any kind of engineering equipment, and of a very high quality, these establishments cannot possibly cope with the present needs, and some of the French mining men consider that it would be better, in spite of the financial difficulties, to purchase American and British machinery and get back on a running basis as soon as possible.

The problems are very great but the French engineers are highly capable and need little help in the way of engineering advice. They know their problems better than we do, and while they appreciate the offers of engineering assistance, it seems to the writer that what they most need is financial assistance to support their own program of reconstruction.

In closing I cannot but express my great admiration for the splendid character of the French and their cheerful courage under the most fearful misfortunes that have ever come upon a civilized people in modern times. Nothing that the Germans can be compelled to do can remedy the terrific wrongs done in the invaded provinces. Men killed, women and children made to suffer, driven from their lifelong homes, which were destroyed, and the final appalling desolation of a region that was one of the most splendidly developed industrially in the whole world. Great mining plants, picturesque hamlets, and in some cases modern mining villages set in a rich agricultural region with carefully tended gardens and farms, fine roads lined with splendid trees; now all flat and a tangled wilderness of trenches, barbed wire, brick,

and steel. Numerous farms through wide areas have been ruined for many years as the trenching, military mining, and shell craters have buried or blown away the humus, leaving exposed the chalks and marls.

We can only wish our French friends as speedy a recovery from their wounds as possible and so far as possible we should help them to recover in their own way.

FIG. 20.

Camphausen Colliery (former Prussian State mine) in the Saar, showing reinforced concrete head house with 1200 h. p. electric hoist in top.

PRESENT FUEL NEEDS OF FRANCE

Before concluding I will chiefly rehearse the fuel needs of France since the United States is the only country (when we recover from the effects of the suspension of work at our coal mines) that can fill the needs, the shortage of shipping being taken into account. While the loss of output of the destroyed mines, 20,000,000 tons per annum, is a huge amount for France, it is relatively small as compared with the total production of Europe, 614,000,000 tons prior to the war.

Although other mining regions in Europe have not been devastated, their production is suffering most seriously from other causes. In central Europe, owing to military and political conditions, the situation is in a dreadful tangle. In Westphalia there have been numerous strikes and troubles, and the output has been

so reduced that Germany has been unable to supply Switzerland and Holland at its doors.

In England the lessening of hours of employment has reduced the year's production about 60 million tons; the exports, amounting to 77,000,000 tons in 1913, have been but 35 million tons and were obtained by curtailing home consumption.

As Mr. Herbert C. Hoover strikingly pointed out in a coal conference held in Paris on August 4, the rate of Europe's production at that time was only 443,000,000 tons, which is only two-

FIG. 21.

Systematically destroyed Micheville Steel Works in the Briey district, France. The only converter not shipped to Germany

thirds of normal on a prewar basis and this would mean a deficiency of 171,000,000 tons. All of Europe does not need coal at prewar rate at this time, but the fuel needs of France are serious.

Numerous estimates have been made which differ materially from one another according to the assumptions made of consumption and imports available. First, regarding consumption: Will France have the same consumption needs as before the war or, because of the destroyed industries, will the country for a few years require less coal? We will assume, however, that the consumption, not including that of restored Alsace Lorraine, will be the same: Coal, coke, and briquettes, 63,000,000 tons, metric. The next point of uncertainty is, what are the needs of Alsace Lorraine. The industries in these provinces were not destroyed and may

go ahead at a maximum rate. Lieutenant Engel, formerly of the French High Commission, recently detailed in the Saar basin, has estimated these requirements (which are the same as submitted by the French Commission to the recent international trade conference at Atlantic City) at 11,000,000 tons. This makes the total requirements for new France about 74,000,000 tons.

During the war the necessity for fuel caused the coal production in other basins of France and the western part of the Pas-de-Calais basin to be raised from 13,000,000 tons in 1913 to 29,000,000 in 1917. During the past winter this intensive production fell off materially and is now at the rate of less than 20,000,000 but is slowly improving to 22,000,000 tons.

ESTIMATED FRENCH PRODUCTION AND IMPORTS FOR YEAR 1919–1920.

	Tons (metric)
Estimated coal production of French mining, say	22,000,000
Estimated surplus from the Saar fiscal mines and Bavarian mines in the Saar	7,500,000
Lorraine production (extension of Saar basin)	3,500,000
Making the total French production	33,000,000
Necessary coal and coke exports to Italy and Switzerland	2,000,000
Available for French consumption	31,000,000
Total French shortage	43,000,000
To meet this deficit Germany is under obligation to furnish 27,000,000 tons, but is not expected (according to the French Industrial Commission at Atlantic City) to be able to supply this coming year more than*	15,000,000
Belgium can probably supply	5,000,000
The French Commission at Atlantic City expressed the hope that England might be able to supply	9,000,000
The deficit, which will have to be furnished by the United States, if all French needs are met, will approximately be 15.4 million short tons or	14,000,000
Total import needs	43,000,000

* In February 1920, press dispatches indicated that only 600,000 tons per month were being sent by Germany to France. French production for calendar year 1919, 19,538,000 tons, not including Lorraine, and for Lorraine 2,326,000 tons.

PRESENT FUEL SITUATION IN FRANCE.

On account of the difficult fuel situation, the French Parliament has passed a law extending the control of coal distribution for two years, or until the end of 1921. During consideration of the measure, M. Locheur, the Minister for Reconstruction, stated that, although not desiring to be pessimistic, he believed

the crisis would persist until that time. He pointed out that at present the production in the Saar was 50 per cent., that of Westphalia 60 per cent., and of the whole of France not more than 70 per cent. of the previous output, omitting the wrecked mining district. Some of these mines have evidently been in part recovered as M. Locheur stated they were now producing at the rate of 700,000 tons annually.

In September the French output was only 1,600,000 tons, which was less by 600,000 tons than the tonnage raised in certain months during the war, but he anticipated a steady increase in the output through the introduction of foreign labor, agreements having been arranged with Poland and Italy.

Germany, the Minister said, was now sending to France 20,000 tons a day. This would be at the rate of 6 million tons per annum. He put the loss to France alone, through strikes in France, England and Germany at no less than 7 million tons.

The cost of the various coals which France was consuming was as follows (September, 1919):

French	70 francs
German	50 francs
British	150 to 160 francs
American	280 francs

During the first eight months of the present year (1919) French coal and coke imports were as follows:

Imports:	Production for year 1919 First 8 months Tons	Estimated total year Tons
Coal	10,510,146	15,700,000
Coke	403,286	600,000
Briquettes	942,198	1,400,000
	11,855,630	17,700,000*
Exports:		
French and foreign coal	1,152,585	1,700,000
Coke	45,396	70,000
Briquettes	52,802	80,000
	1,250,783	1,850,000
Total available (imports over exports)	10,604,847	16,000,000

*_Echo des Mines_ reports (Jan., 1920) imports for 1919 were 18,601,000 tons.

With a deficiency of 43,000,000 tons, unless imports are speeded up, it is evident that our French friends must go without heat in their homes and forego many things that are regarded as necessaries of modern civilization.

NOTE ON BRANNERITE.*

BY

ROGER C. WELLS, Ph.D.,

U. S. Geological Survey

THE mineral brannerite described in a recent paper in this JOURNAL[1] was carefully tested for helium, as it was expected that a mineral consisting of nearly 50 per cent. of the oxides of uranium, and also containing thorium, should show at least a trace of helium. None was found, however, by the method employed. It was found that some sulphur dioxide was produced by reaction of the mineral and sodium bisulfate, and after removing this with a solution of sodium hydroxide, the remaining gas did not show the characteristic yellow line of the helium spectrum. Shortly after the paper was published the advantages of purifying the evolved gases by means of charcoal and liquid air were brought to the attention of the writer by Dr. R. B. Moore of the Bureau of Mines, and it seemed desirable to repeat the test, using this method. Some highly active charcoal was kindly furnished by Prof. A. B. Lamb of the Fixed Nitrogen Research Laboratory, American University, for the purpose. The clean-up of the gas by this method gave a decisive result indicating the presence of helium, which places the mineral in the list of uranium minerals in which helium has been identified. The test was conducted as follows:

About 5 grams of brannerite was powdered and mixed with previously fused sodium bisulfate in a hard glass tube which was connected by a thick rubber tube to the Töpler pump. Between the hard glass tube and the pump were three stopcocks, and between the latter were sealed the tube containing the charcoal and a spectrum tube, respectively. The system was evacuated until a pressure of about 0.05 mm. was permanently obtained while the charcoal was heated. The spectrum tube and pump were then cut off leaving the stopcock between the charcoal and mineral open while the bisulfate was gently fused. The tube of charcoal was then allowed to stand in liquid air for about half

* Published by permission of the Director, U. S. Geological Survey.

[1] Hess and Wells, this JOURNAL, Feb. 1920, p. 230.

an hour to effect a clean-up of the gas. Finally the gas was admitted to the spectrum tube and a little later the tube was sealed off.

The yellow helium line showed up strongly in the spectrum, and several other lines believed to belong to helium were noted. These observations were made with a spectroscope having an illuminated scale and the wave-lengths were read from a curve based on some familiar flame spectra. The method does not give more than three significant figures. The values found ascribed to helium were 6660, 5880, (yellow line), 5030, 4720, and 4470. Two lines, 6545 and 4870 may represent hydrogen, whereas 6070, 5620, and 5200 are believed to belong to carbon. Among other lines noted but not placed are 5470 and 7000. The spectrum may be examined more carefully later if it should appear desirable but the first object in view was to establish the presence of helium.

At the conclusion of the experiment it was found that approximately half of the mineral taken was decomposed by the short fusion with the bisulfate.

Peat. (*U. S. Geological Survey, Press Bulletin No. 445.*)—The uses of peat are numerous and varied. In the countries of northern Europe it is used for fuel and as the basis for many manufacturing industries. Gas, charcoal, coke, and a number of valuable by-products are produced from it. Owing to the scarcity of raw materials in Europe, peat and peat moss are also employed as substitutes for absorbent cotton in the preparation of surgical dressings, for wood and for cotton and woollen cloth.

In the United States peat is utilized chiefly as fertilizer and fertilizer filler, as stable litter, and as an absorbent for the uncrystallized residues of beet and cane sugar refineries in the manufacture of stock feed.

Peat has long been used in fertilizing the soil, having been either applied as a direct fertilizer or used as a filler for commercial fertilizer. Analyses of the peats of the United States show an average nitrogen content of about 2 per cent., a proportion somewhat higher than that found in some commercial fertilizers. The value of peat in soil fertilization is found in its nitrogen content and in the beneficial mechanical effect it produces upon certain lands. Black, thoroughly decomposed peats are most satisfactory for fertilizer, as such peats are generally heavier and more compact and contain more nitrogen and less fibrous material than the brown types.

NOTES FROM THE U. S. BUREAU OF STANDARDS.*

PICNOMETER FOR DETERMINATION OF DENSITY OF MOLASSES.[1]

By W. B. Newkirk.

[ABSTRACT.]

THE determination of the density of molasses has been very inaccurate in previous times. The difficulties which are the cause of these inaccuracies are the high viscosities in the molasses, the dissolved gases which it contains, and the included air which is introduced in mixing.

A picnometer bottle was designed to overcome these difficulties. The volume of the picnometer was controlled as in the picnometer of Johnson and Adams.[2] To this bottle was attached an expansion chamber designed by an anonymous writer [3] and to the expansion chamber was fitted a connection leading to a vacuum. In operation, all ground glass joints are lubricated with the sample to be analyzed. The picnometer and expansion chamber are filled until the expansion chamber is about one-third full. Sufficient vacuum is then applied to liberate all the gases contained in the sample. The apparatus is then sealed from the vacuum source and allowed to remain until all the gas has arisen to the expansion chamber. The volume is then fixed under standard conditions. Results from the use of this picnometer are such that agreements within a few hundredths degrees Brix can be obtained.

It was found that heating causes some unknown decomposition to take place, changing the density of the resulting molasses. The vacuum, when sealed shortly after applying, causes no decomposition and permits a perfect separation of the gases contained in the sample. Several experiments are given, showing the accuracy with which analysis can be made.

* Communicated by the Director.

[1] Technologic Paper No. 161.

[2] *Jour. of Am. Chem. Soc.*, **34**, 566, 1912.

[3] *International Sugar Journal*, **15**, p. 489, 1913.

A NEW SPECTRO-PYRHELIOMETER OF THE MEASUREMENTS OF THE COMPONENT RADIATIONS FROM THE SUN AND FROM A QUARTZ MERCURY VAPOR LAMP.[4]

By W. W. Coblentz and H. Kahler.

[ABSTRACT.]

IN this paper a new spectro-pyrheliometer is described, and data are given showing the applicability and the performance of the instrument.

The apparatus consists of a quartz spectrograph and a cylindrical condensing lens, placed upon a simple equatorial mounting. The collimating telescope is pointed directly at the sun, thus avoiding the ultra-violet absorption, which occurs in heliostat mirrors. The radiometric measurements were made by means of a bismuth-silver thermopile of special design.

Data are given on the relative components of the infra-red, visible, and ultra-violet radiation from the sun and from a quartz mercury arc lamp; also data on the ultra-violet component radiation from a gas-filled tungsten lamp, the iron arc and the carbon arc. These data are of interest in dye-fading and other photochemical tests.

In two appendices, methods are given for excluding ultra-violet light from buildings (*e.g.*, balloon hangars) and for protecting projection lantern films from the heat of the lamp.

NOTES ON THE CRITICAL RANGES OF SOME COMMERCIAL NICKEL-STEELS.[5]

By H. Scott.

[ABSTRACT.]

THE transformations in some commercial nickel steels have been studied by means of thermal analysis. The Ac_3 transformation, the temperature of which is of direct practical value in heat-treatment specifications, is also the most difficult to definitely locate. It is found that slow rates of heating give better definition of this point and that the end of the Ac_3 range, as interpreted from the thermal curves, corresponds to the minimum

[4] Scientific Paper No. 378.
[5] Scientific Paper No. 376.

temperature at which all the ferrite is in solution. The effect of rate of temperature change and of nickel content on the critical ranges of the steels, which approximate 0.40 per cent. C content, is shown in curves, and the effect of nickel and carbon on the end of Ac_3 is deduced from the data obtained and that of other observers whose work is discussed. The effect of nickel on the A_1 transformation is to lower Ac_1 by 10.5° C. and Ar_1 by 21.5° C. for each 1 per cent. nickel over the range 0 to 4 per cent. nickel. The eutectoid ratio is also decreased by 0.42 per cent. C. for each 1 per cent. nickel added over the same range.

THE POROSITY AND VOLUME CHANGES OF CLAY FIRE BRICKS AT FURNACE TEMPERATURES.[8]

By George A. Loomis.

[ABSTRACT.]

THIS paper deals with the permanent changes in porosity and volume of clay fire bricks when reburned to temperatures at or above those to which they were originally fired. These were measured for a series of temperatures to determine what relation, if any, might exist between these changes and the deformation of the same bricks under load at furnace temperatures. The possibility of such a relation is suggested by the fact that contraction of clay on heating and decrease in porosity are, to a certain extent, indications of the amount of softening of the mass due to the action of fluxes present and hence indicative of decreased resistance to deformation under pressure or decreased viscosity. Softening point determinations were also made to determine what relations these might bear to the results of the load test.

The results of tests on a large number of clay fire bricks from various parts of the country show that bricks which withstand a load test of 40 pounds per square inch at 1350° C. without marked deformation show no marked changes in porosity or volume up to 1425° C. Bricks which do not withstand the test generally show appreciable contraction or expansion, accompanied by considerable decrease in porosity. Bricks which showed overburning and the development of vesicular structure below 1425° C., by marked expansion or increase in porosity, invariably

[8] Technologic Paper No. 159.

failed under load. In general, bricks which show a decrease in porosity exceeding 5 per cent. or a volume change exceeding 3 per cent. (amounting to approximately 1 per cent. in linear dimensions) when refired to 1400° C. fail to pass the load test.

No definite relation could be determined between the softening point of a brick and its ability to withstand pressure at high temperature. All bricks softening below cone 28 failed completely in the load test. Some showing quite high softening points also failed, probably due to the use of an inferior bond clay in the mixture or too small an amount of bonding material.

THE EFFECTS OF OILS, GREASES, AND DEGREE OF TANNAGE ON THE PHYSICAL PROPERTIES OF RUSSET HARNESS LEATHER.[1]

By R. C. Bowker and J. B. Churchill.

[ABSTRACT.]

TECHNOLOGIC PAPER No. 160 of the Bureau of Standards contains a description of methods used and presents the results obtained in an investigation to determine the effects of the use of animal and mineral oils, of the amount of stuffing content, and of the degree of tannage on the physical properties of russet harness leather.

Three hides were prepared for the work, one for each test as mentioned above. The method of using double backs was used so that when split and each back was given its special finishing treatment the two leathers compared would come from the same hide. The hide used for studying the effect of the amount of stuffing content on the physical properties consisted of one back which contained an average of 10.7 per cent. and one back which contained an average of 23.35 per cent. To study the effects of the degree of tannage on the physical properties, a hide was split during the tanning process and one back was removed while the other was allowed to remain in the vat a month longer. Both backs were finished in the same manner. The hide used to study the effects of the use of animal and mineral oils on the physical properties consisted of one back stuffed with a mixture

[1] Technologic Paper No. 160.

of 50 per cent. cod oil and 50 per cent. tallow and one back stuffed with a mixture of 50 per cent. Breton mineral oil and 50 per cent. tallow.

The experimental work consisted of a series of tensile strength, percentage stretch, buckle strength, and chemical tests from definite locations on the hide. Results are presented which show the variation in the physical properties over the hide and also the variation of the stuffing content over the hide. The manner in which the physical properties are affected by the treatment of the leather is discussed in detail.

The results of the test indicate that the amount of stuffing content up to a certain limit will serve to increase the strength of the leather after which it does not have this effect and may serve to decrease the strength. It is also shown that the leather given a longer tannage has a lower tensile strength but will have a greater resistance to shearing action. The results of the test to show the effects of the use of animal and mineral oils in the stuffing showed that there were no appreciable effects on the physical properties of the new leather.

THE INTERCRYSTALLINE BRITTLENESS OF LEAD.[1]

By Henry S. Rawdon.

[ABSTRACT.]

SHEET lead sometimes assumes a very brittle granular form during service, due to corrosion. An explanation which has been offered by previous investigators for this change in properties is that it is due to an allotropic transformation, the product resulting from the change being analogous to the well-known "gray tin." Contact with an electrolyte, particularly a weak acid solution of a lead salt, has been claimed to be the agency by which the transformation is brought about.

Metallographic examination of the granular "allotropic" lead shows that each grain has the characteristic properties of the ordinary form of lead. The intercrystalline cohesion of the grains for one another, however, has been so weakened that the material has a granular appearance.

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[1] Scientific Paper No. 377.

The rate at which the intercrystalline brittleness is brought about is proportional to the amount of impurities and to the concentration of acid in the solution in which the lead is placed. Practically all the impurities which are found in lead are lodged in between the grains. The preferential attack by the corroding agent for these impurities and perhaps also for the "amorphous intercrystalline cement" accounts for the brittleness produced. Investigation showed that specimens of exceptionally pure lead (99.993 per cent), when immersed for 24 days in a neutral solution of lead acetate, became appreciably embrittled by the formation of minute intercrystalline fissures. No evidence of the existence of an allotropic form of lead similar to gray tin could be obtained.

Milk Products in America and Europe.—A recent investigation of this field is given in a report by W. DEMPSTER, published in the *New Zealand Journal of Agriculture*, 1920, XX, 97–109. Milk powder is manufactured by the use of heated rolls, or by spraying the previously concentrated milk into a hot chamber. In addition to its other uses in the food industries, skim milk powder or dried skim milk is used with butter in reconstituting milk and cream during seasons of scarcity of fresh milk. In the manufacture of reconstituted cream, the proper amounts of skim milk powder and water are placed in a jacketed vat and are intimately mixed by a propeller which revolves at a high speed. The speed is reduced, the proper amount of butter added, and the temperature of the mixture gradually raised to 145° F., kept constant for twenty to thirty minutes, then lowered to 135° F. The mixture is next put through a homogenizer, and immediately cooled to 45° F. In reconstituting milk, the skim milk powder and water are mixed as just described; the butter, which has been heated to a temperature of 120° F., is now forced through a spray nozzle which lies beneath the surface of the liquid; the finely divided butter fat is uniformly distributed throughout the reconstituted milk. Whole milk powder apparently does not keep well; it seems to require cold storage, *e.g.*, 0 to −8° F., for its preservation. During the war, the production of lactose or sugar of milk increased enormously, since large amounts of that compound were used in the manufacture of smoke-shells. The casein industry of America centres in Philadelphia; this milk protein may be used as the basis of paints, which may be produced in any desired color, withstand water, and retain their color. The shortage of butter in England increased the demand for sweetened condensed milk, which was eaten spread on bread.

J. S. H.

NOTES FROM NELA RESEARCH LABORATORY.*

NOTE ON THE EFFECT OF LACK OF WHITENESS IN THE PAINT AND WINDOW OF THE ULBRICHT SPHERE.

By F. E. Cady.

THE theory of the Ulbricht sphere as used in determining the mean spherical candlepower of lamps, calls for an inner surface which is perfectly diffusing and non-selective as to color. These conditions are only approximated in spheres as actually constructed and used. Most white paints change their color with age, and it seems desirable to know how much error an appreciable departure from whiteness will cause when measuring lamps differing in integral color value, as for instance in comparing gas-filled tungsten lamps with vacuum tungsten lamps.

A test of this effect was made using an 80-inch sphere, with a painted inner coating such that its color differed from white as much as a tungsten lamp would change in color if operated at a temperature approximately 200° lower than normal. The window of the sphere had a selective transmission which changed the color of the transmitted light by approximately the same amount. Two different methods were used. One consisted in determining the mean spherical candlepower of some lamps colored so as to have their light match that of a kerosene flame, in terms of normal vacuum tungsten lamps, first with an ordinary photometer and then in the sphere. The other method consisted in getting the ratio of a colored lamp to a normal vacuum lamp, each having been previously measured in terms of a comparison lamp of the same color. Measurements were made on the regular photometer and in the sphere.

The results showed an error due to the selectivity of the paint and the window of 4.5 per cent. by the first method and 5.0 per cent. by the second. Part of the small discrepancy could be accounted for by aging of the paint during the month or so which elapsed between the tests by the two methods. It is concluded that where the color differences are not more than those occurring in the measurement of gas-filled lamps in terms of vacuum lamps, the paint can depart appreciably from whiteness without causing a very large error.

* Communicated by the Director.

NOTE ON SPEED OF FLASHING OF INCANDESCENT SIGNAL LAMPS.

By A. G. Worthing.

A PORTION of a study of the theory of signaling units involving incandescent lamps, which was undertaken in response to a request from the National Research Council and the U. S. Signal Corps for the development of a unit for use in daylight signaling is herein given.

Filament Characteristics Involved.—Various factors involving speed where the telegraphic dot and dash signals are produced by the flashing of an incandescent lamp, are discussed in a broad way in a contrast of tungsten with carbon for filament material. Most important are (1) the change in resistance with change in temperature, (2) the quantity of energy required to heat the filament through a given temperature range, (3) the total emissive power of the filament material, (4) the maximum temperature of a flash, and (5) the efficiency of the radiation in producing vision. For lamps of equal voltage, life and luminous flux, tungsten is favored during the heating portion of a flash by a factor of six or seven.

Observed Speeds and Their Comparison with Expected Values.—A photometric method of studying the performance of lamps on flashing is described and the results obtained with various lamps are presented. These are compared with computed values based on steady current measurements and the supposition that a lamp filament on heating or cooling passes through a succession of steady states. The agreement is quite satisfactory, when there is excepted the case of a filament immersed in hydrogen, where the discrepancy may be ascribed to ionization effects.

Speed Functions.—It is further shown that a simple function involving only steady current measurements of wattage, resistance and temperature in the neighborhood of the maximum temperature of a flash, together with the thermal capacity of the filament, will serve quite accurately in rating various lamps as to their flashing speeds.

Some Fundamental Generalizations.

(1) The time required for a filament to heat to approximately its maximum brightness exceeds greatly the time required in cooling to effectively zero brightness.

(2) The higher the maximum temperature of a flash, the greater is the speed of the flash.
(3) The smaller the filament, the greater is the speed of the flash.
(4) The less the resistance in a circuit external to the flashing lamp, the greater is the speed of the flash.
(5) The speed of flashing for a given filament at a given temperature in various atmospheres—including in vacuo—is the greater, the greater the gas loss.
(6) For lamps of the same open filament construction in various atmospheres, such that they possess the same luminous flux and the same average life at the same fixed voltage, the speed of flashing is the greater, the greater the gas loss.

Ribbon Filaments Versus Wire Filaments.—Due to the quantity of material in a ribbon filament being much less than that in an equivalent wire filament, one should expect in going from a wire filament to a ribbon filament, either a considerable increase in signaling speed, or, without a reduction in speed in gas-filled lamps, a possibility of change in atmosphere to one involving a decreased gas loss (higher efficiency). A contrast of a lamp containing a ribbon filament in argon as proposed by the Nela Research Laboratory in response to the request noted above, with that lamp which was its nearest competitor indicated speeds and efficiencies in favor of the former lamp of the order respectively of 1.6 and 1.25.

The Detection of Finger Prints on Documents.—C. AINSWORTH MITCHELL (*Analyst*, 1920, vol., xlv, 122) has made an extensive study of the methods of rendering finger prints more conspicuous. The extensive adoption of the finger-print method of identifying human beings has led to a stereotyping of the methods and tended to discourage experimental investigation. Mr. Mitchell commends the comparison method introduced by A. S. Osborn, of New York City, by which the resemblances are clearly shown by photographs beneath small squares of ruled glass. A point brought in the present paper is the persistence of the characteristic papillary ridges throughout a long life, in connection with which statement two pictures are shown, being finger prints of Sir William Herschel in 1861 and 1914, respectively. The latter print shows marked weathering of the ridges and some transverse cracks due to age, but the patterns agree in all

essential details. It was Herschel who first introduced the use of finger prints as a safeguard on documents, but the first systematic investigation of the subject and the use of accidental prints as a means of identifying individuals, is due to Dr. Henry Faulds, whose work has been generally overlooked. Faulds paid special attention to the question of "developing" the prints, and suggested the use of certain reagents. The points on which there has been heretofore but little positive information are: (1) The most suitable method for detecting latent prints, such as those on a book. (2) After what period of time is it possible to detect the marks on different qualities of paper. The marks made even by heavy pressure upon the leaves of a book cannot, as a rule, be shown up directly by photography with oblique illumination, and some method of increasing the contrast is required.

The English official method is to dust the surface with a very fine powder, light or dark, according to conditions. A mixture of chalk and the "gray" powder of the pharmacist (a form of mercury) is used for dark surfaces, and finely powdered graphite for light surfaces. Faulds found that a mixture of fine graphite and lampblack gave excellent results. Stokis recommended lycopodium with 10 per cent. of Sudan red. The results with these methods depend much upon the nature of the paper. With highly glazed paper the prints seem to be fairly permanent, and Mitchell has developed them satisfactorily with methylene blue after three years. Highly sized and clayed papers are less liable to retain the impressions.

Since the prints always contain minute amounts of organic matter, especially fatty matters, osmic acid has been suggested as a developer, and has been found efficient in many cases. Mitchell uses a 1 per cent. solution in water, brushed over the print and then exposed to sunlight, by which the ridges become dark, while the furrows are not colored. The method is less effective after long periods. Ink has been used as a developer, but conflicting results have been obtained by different investigators, due probably to the great differences in commercial ink. Mitchell recommends a standard ink made by diluting 2 c.c. of the standard osmic acid reagent for microscopy with an equal volume of water and adding 0.05 gram of pyrogallol. The liquid is ready for use at once, and should be spread over the paper with a soft brush.

Mitchell found that one of the most sensitive reagents is iodine vapor, thus confirming results that had been previously obtained by other investigators. The prints so brought out are, however, fugitive and not easy to photograph. Mercuric iodide vapor was found to be better. The vapor of osmic acid is a very active developer, and is particularly efficient in bringing out the relations, size, and other data concerning the pores, a feature which has been especially applied by Dr. Locard, of Paris.

H. L.

NOTES FROM THE U. S. BUREAU OF CHEMISTRY.*

STUDIES IN NUTRITION. II: THE RÔLE OF CYSTINE IN NUTRITION AS EXEMPLIFIED BY NUTRITION EXPERIMENTS WITH THE PROTEINS OF THE NAVY BEAN, PHASEOLUS VULGARIS.[1]

By Carl O. Johns and A. J. Finks.

[ABSTRACT.]

NUTRITION experiments with the proteins of the navy bean, *Phaseolus vulgaris,* show that they are deficient in cystine. Normal growth is produced if 2 per cent. of cystine is added to cooked phaseolin, the chief protein of the navy bean, or to cooked navy bean meal, if an amount of cystine equivalent to 2 per cent. of its protein content is added, when these furnish the sole source of protein in an otherwise complete diet. Neither uncooked phaseolin nor navy bean meal furnishes adequate protein for growth, even when cystine and the non-protein dietary essential are added. Cystine is thus shown to be an essential amino-acid for normal growth.

THE DETERMINATION OF IODIDE AND BROMIDE IN MINERAL WATERS AND BRINES.[2]

By W. F. Baughman and W. W. Skinner.

[ABSTRACT.]

IODIDE is oxidized to iodate by potassium permanganate in slightly alkaline solution, and the iodate determined iodometrically by adding potassium iodide, acidifying with hydrochloric acid, and titrating the liberated iodine with thiosulphate. For the bromide determination another sample which should not contain more than 0.1 gram of bromine or more than 10 grams of total salts is taken. The iodine is removed from this sample by oxidiz-

* Communicated by the Chief of the Bureau.

[1] Published in *J. Biol. Chem.*, **41** (1920), 379–389.

[2] Published in *J. Ind. Eng. Chem.*, **12** (1920), 358.

ing with ferric sulphate and distilling the liberated iodine with steam. The iodine may be absorbed in a potassium iodide solution and titrated with thiosulphate. The results for iodine obtained by this method are not as accurate as those obtained by the permanganate method (*J. Ind. Eng. Chem.*, 11, 1919, 563). The residue in a distilling flask is emptied into a beaker, heated to boiling, and the iron precipitated with ammonia or sodium hydroxide. The iron hydroxide is removed by filtration and washed with hot water. The filtrate is evaporated to dryness, or nearly so, and the bromine determined in the residue by the chromic acid method (*J. Ind. Eng. Chem.*, 11, 1919, 954). Results of determinations of from 0.04 to 0.08 gram of iodine as iodide and from 0.001 to 0.1 gram of bromine as bromide in the presence of 10 grams of sodium chloride are tabulated.

STUDIES IN NUTRITION. III: THE NUTRITIVE VALUE OF COMMERCIAL CORN GLUTEN MEAL.[3]

By Carl O. Johns, A. J. Finks, and Mabel S. Paul.

[ABSTRACT.]

COMMERCIAL corn gluten meal has been shown to contain adequate proteins for normal growth, but it is lacking in water-soluble vitamines. This deficiency, however, was corrected by the addition of either 3 per cent. of dried brewer's yeast or 18 per cent. of whole gound yellow cornmeal. The addition of cocoanut press-cake to the corn gluten meal furnished the necessary water-soluble vitamines, as well as a very efficient mixture of proteins.

Overseas Touring Exhibitions. (*Electrician*, March 26, 1920.)—For the purpose of bringing British goods to the attention of foreign countries, four traveling exhibitions will be arranged. The first will leave England in June of this year and will return two years later after having visited South Africa, Australia, New Zealand, and Canada. Three other tours will go to the United States, the Far East, and South America. The displays are to be on view for about two weeks in each city where a halt is made.

G. F. S.

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[3] Published in *J. Biol. Chem.*, 41 (1920), 391–399.

NOTES FROM THE U. S. BUREAU OF MINES.*

THE DETERMINATION OF MERCURY.

By C. M. Bouton and L. H. Duschak.

THE volumetric methods for the determination of mercury described in the literature permit the selection of a variation of about 1 mg. of Hg. or within 0.1 per cent. on a 1-gram sample. As much of the world's supply of the metal is obtained from ores carrying less than 1 per cent. mercury, a method that will quickly and accurately determine a variation of less than 1 mg. Hg. is greatly to be desired. Of the numerous methods tested by the investigators of the Berkeley, Calif., stations of the Bureau of Mines in connection with a study of mercury condenser losses, the method of titration with potassium thiocyanate, using ferric sulphate or nitrate as an indicator, proved to be the only one capable of the desired refinement. The titration is vitiated by the presence of any halide; therefore, in bringing the sample into solution, a method must be employed which absolutely excludes all halogen compounds. With slight modification, the method can be applied to the determination of mercury in practically any material, including that containing considerable quantities of organic matter. Details as to the equipment used, analytical procedure, the modifications necessary when organic matter or much sulphur is present, procedure for assaying a filtered precipitate, alternative procedure for refractory samples; and the results of experimental determination of distillation procedure, effects of evolution of gas, possibility of retention of mercury by the charge, trial assay with sulphur and organic matter present, interfering elements, and titration are given in Technical Paper *227* of the Bureau of Mines. With readily provided facilities one operator can make 50 to 60 determinations in an eight-hour day, exclusive of the time required for preparing the sample. Technical Paper *227* also includes a bibliography on analytical methods for the determination of mercury.

* Communicated by the Director.

APPROVED EXPLOSION-PROOF COAL-CUTTING EQUIPMENT.

By L. C. Ilsley and E. J. Gleim.

THE chance of igniting "fire damp," an explosive mixture of methane and air, is the greatest at the working face is a coal mine, where coal-cutting equipment finds its only use. In the United States the development of apparatus for use in gaseous mines has been associated largely with coal-cutting equipment run by electricity. Direct-current motors and alternating-current motors of the slip-ring type when running usually give off electric arcs or flashes that will ignite fire damp. Other motors that have no moving electric contacts may become dangerous through accident, deterioration, or neglect. Auxiliary apparatus, such as fuses, switches, rheostats, and controllers, may arc, flash or become heated to such a degree that fire damp can be ignited. Such equipment is still more dangerous when worn or out of repair.

Danger of causing explosions may arise from lack of protection, weak mechanical construction, incorrect ideas of what constitutes adequate protection, amount and arrangement of internal unoccupied space, the compression of the gas with the machine, and the percentage of gas and the amount and distribution of coal dust. The chief problem of the manufacturer of apparatus suitable for fire damp atmospheres is that of extracting heat from possible explosive flames and cooling them below the ignition temperature of methane as they pass through the openings. Gas light apparatus is not practicable for mine service, because of the difficulty of inspection and making renewals. Totally enclosed apparatus has the advantages of simplicity of design, slight deterioration, and freedom for excessive dust troubles. Partly enclosed apparatus is provided with openings in which are placed heat-abstracting devices. These afford a certain amount of ventilation. The design and maintenance of safe heat-abstracting devices is the chief problem of apparatus of this class. Schedule 2A of the Bureau of Mines, stating the procedure for establishing a test of permissible explosion-proof motors, was issued November 2, 1915, and the investigation made under its regulations are described in Bulletin 78 of the Bureau of Mines. These include tests made on explosion-proof motors, coal-cutting equipment and locomotives.

MINING AND PREPARING DOMESTIC GRAPHITE FOR CRUCIBLE USE.

By Geo. D. Dub and F. G. Moses.

Before 1915 nearly all the graphite used in crucible manufacture in the United States was imported, the small domestic output being used for lubricants, paints, foundry facings, and other purposes, but the combination of large demand for crucibles and the short life of crucibles made from other than the Klingenberg clay, no longer attainable, lead to its use in greatly increased quantities. The War Industries Board finally ruled that 20 per cent. domestic flake graphite should be used in crucible mixture during 1918 and 25 per cent. during 1919. Alabama, New York, Pennsylvania and Texas were the principal producing states, there being thirty-nine plants in three counties of Alabama. New York, which for many years had been the principal source of domestic production, had only three mines in operation in 1918, having yielded first place to Alabama. In Pennsylvania five plants were in operation in Chester County. While in Texas, three properties were active, in 1918, in the central region between Llano and Burnet. Details as to these operations, methods of concentration of the ores, the preparation of domestic graphite for crucible use, are given in Bulletin 112 of the Bureau of Mines. The method of rapid analysis of graphite used by the Bureau of Mines is also described. There are four methods of concentrating graphite ores, water "skin flotation," the pneumatic process, the log-washer process, and oil-froth flotation. The product of the first concentration is a comparatively low-grade concentrate. The second step, finishing, as it is called, is much more difficult to carry out, and is the one that demands the greatest amount of investigation and improvement. Much experimental work on the preparation of Alabama graphite was carried on at the Salt Lake City station of the Bureau of Mines by F. G. Moses. The whole success of a finishing process depends on the removal of a large percentage of coarse hard impurities that tend to cause excessive destruction of valuable flake in the buhr-mill grinding. Details as to the investigations and the processes recommended are given in the bulletin of the Bureau of Mines already referred to.

Potash Deposits in Spain. (*U. S. Geological Survey Press Bulletin, No. 443,* April, 1920.)—Potash deposits were discovered a few years ago in the Province of Barcelona, Spain, near the villages of Suria and Cardona. They consist of irregular beds of carnallite and sylvinite interbedded with rock salt. Explorations to a depth of several hundred feet show that in the Suria district potash beds occupy an area of not less than 75 acres and occur at depths from 125 to 200 feet. The average combined thickness of the carnallite beds is estimated to be about 56 feet, and of the sylvinite about 13 feet. The Cardona upper beds are interbedded with gypsum and clay, but the lower beds contain nearly pure white salt, which is that principally mined. After the discovery of potash at Suria, these Cardona beds were searched for potash, and nearly pure sylvite was found. Estimates for the area prospected place the quantity of carnallite at 2,550,000 tons and of sylvinite at 1,150,000 tons.

Aluminum honeycombs are frames in which thin strips of aluminum are ingeniously worked into the shape of worker-cells. The surface of these cells is slightly brushed with beeswax; the bees build on these edges until the combs are of such depth as the spacing of the frames will permit. The metal combs are claimed to enable a greater production of honey, since time is saved in building the wax, and they extract cleaner and do not break. In experiments on aluminum honeycombs, conducted by G. V. WESTBROOKE (*New Zealand Journal of Agriculture,* 1920, xx, 118–119), light honey was readily extracted from the combs. In combs with thick honey, when extra speed was applied to the extractor, most of the honey was obtained; only a few cells retained a small amount; the combs showed no signs of breaking in spite of the high speed of the extractor.

J. S. H.

The Output in Sawing Metals by Hand. CH. FREMONT. (*Comptes Rendus,* March 22, 1920.)—It takes less time to saw a rectangular bar of steel when the saw is moved parallel to the shorter side of the rectangle than when it moves parallel to the longer side. Further, the output grows less as the length of the saw cut lengthens. The same workman who sawed the steel of a rail at the rate of 3.4 sq. cm. per minute when the cut was 1 cm. long, dropped to 1.25 sq. cm. when the cut was 10 cm. in length. The output per minute decreased regularly by .25 sq. cm. for each increase of 1 cm. in the length of the cut.

When the end of the saw away from the workman was supported not by his hand but by a simple pendular device it was found that the time required for sawing was shortened, a thinner blade could be used, and a better surface resulted.

G. F. S.

THE FRANKLIN INSTITUTE.

(Proceedings of the Stated Meeting held Wednesday, May 19, 1920.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, MAY 19, 1920.

PRESIDENT DR. WALTON CLARK *in the Chair.*

By consent, the reading of the minutes of the previous meeting was dispensed with.

Additions to membership: 6.

The President announced that the business of the meeting would be the annual presentation of The Franklin Medal, the Institute's highest award in recognition of distinguished and scientific achievements, and called upon Dr. Harry F. Keller, who gave an account of the work of the Honorable Sir Charles A. Parsons, K.C.B., C.B., M.A., LL.D., D.Sc., F.R.S., of Newcastle-on-Tyne, England, recently recommended by the Institute's Committee on Science and the Arts for The Franklin Medal in recognition of "His epoch-making success in the development and construction of the steam turbine, which has revolutionized the art of steam engineering, particularly in regard to the propulsion of mercantile and naval vessels and the driving of electrical generators."

Sir Auckland Geddes, British Ambassador, was then presented to the President, and received from him The Franklin Medal awarded to the Honorable Sir Charles A. Parsons. His Excellency conveyed the thanks of his Government for the honor conferred upon his distinguished countryman, and said that such gracious acts went far to insure the continuance of the happy relations which have so long obtained between Great Britain and America.

Doctor Keller was again recognized, and described the work of Professor Svante August Arrhenius, Ph.D., M.D., D.Sc., LL.D., of the Nobel Institute, Stockholm, Sweden, who had also been awarded The Franklin Medal, in recognition of "His notable contributions to the theory of physical science, which have found unprecedentedly extended and fruitful application in the experimental study of chemical, physical, biological and cosmic phenomena, as well as in industrial chemistry," and introduced Mr. Joen de Lagerberg, Secretary of the Swedish Legation at Washington, who accepted The Franklin Medal and extended the appreciative thanks of His Swedish Majesty's Government for the honor done Professor Arrhenius.

The paper, "Some Reminiscences of Early Days of Turbine Development," by Sir Charles A. Parsons, was read by Mr. Charles Day, Vice-President of the Institute.

The paper, "The Problem of the World's Supply of Energy," by Professor Svante August Arrhenius, was read by Dr. Allerton S. Cushman, Director of The Institute of Industrial Research, Washington, D. C.

Adjourned.

R. B. OWENS,
Secretary.

(A full account of the meeting will appear in the next issue of the JOURNAL.)

COMMITTEE ON SCIENCE AND THE ARTS.

(*Abstract of Proceedings of the Stated Meeting held Wednesday, May 5, 1920.*)

HALL OF THE INSTITUTE,
PHILADELPHIA, May 5, 1920.

MR. CHARLES PENROSE *in the Chair.*

The following report was presented for final action:

No. 2747: Principles of Concealing Coloration. Advisory.

The following report was presented for first reading:

No. 2748: Bullard Mult-Au-Matic.

R. B. OWENS,
Secretary.

MEMBERSHIP NOTES.

ELECTIONS TO MEMBERSHIP.

(*Stated Meeting, Board of Managers, May 12, 1920.*)

RESIDENT.

MR. CHARLES PHILIP BOWER, Civil Engineer, 403 Westview Avenue, Germantown, Philadelphia, Pennsylvania.

MR. WARREN MATHEWS FOOTE, President, Foote Mineral Company, and for mail, Swarthmore, Pennsylvania.

MR. FRANK H. STEWART, Textile Manufacturer, in care of Krout & Fite Manufacturing Company, 1950 East Allegheny Avenue, Philadelphia, Pennsylvania.

NON-RESIDENT.

MR. ISAAC W. BYERS, Retired, Iron River, Michigan.

ASSOCIATE.

MR. JULIUS COHEN, Chemist, 5605 Wyalusing Avenue, Philadelphia, Pennsylvania.

MR. FRANCIS W. HARTZELL, Carburetted Water Gas Manufacturer, 728 Robbins Avenue, Philadelphia, Pennsylvania.

CHANGES OF ADDRESS.

DR. LUCIUS P. BROWN, Franklin, Tennessee.

MR. R. W. DAVIDS, Merion Station, Pennsylvania.

MR. W. W. DAVIS, in care of Semet-Solvay Company, Syracuse, New York.

MR. EDWIN ELLIOTT, 403 West Price Street, Germantown, Philadelphia, Pennsylvania.

MR. ARMIN ELMENDORF, Haskelite Manufacturing Corporation, 819 Chamber of Commerce Building, Chicago, Illinois.

MR. J. G. FELTON, Manager, Wisconsin-Minnesota Light and Power Company, La Crosse, Wisconsin.

MR. EDWIN FRANK, 5216 Laurens Street, Philadelphia, Pennsylvania.

MR. FRANCIS H. GILPIN, 22 Edgemont Avenue, Summit, New Jersey.
DR. C. J. HEXAMER, The Bartram, 33rd and Chestnut Streets, Philadelphia, Pennsylvania.
MR. FRANKLIN S. HORN, 1515 Arch Street, Philadelphia, Pennsylvania.
MR. H. J. KALTENTHALER, 6457 Woodbine Avenue, Overbrook, Philadelphia, Pennsylvania.
DR. E. F. KINGSBURY, Western Electric Company, 463 West Street, New York, New York.
CAPTAIN CHESTER LICHTENBERG, 137 Park Avenue, Schenectady, New York.
MR. R. A. MARRIOTT, 431 East 10th Street, Long Beach, California.
MR. CHARLES E. RICHARDSON, Charles E. Richardson & Company, Engineers, 25 East 41st Street, New York, New York.
MR. H. R. STANFORD, Naval Operating Base, Hampton Roads, Norfolk, Virginia.
MR. DAVID H. WILSON, JR., 253 36th Street, Brooklyn, New York.

NECROLOGY.

John A. Brashear. By the death of John A. Brashear, astro-physics has lost one of its most skilful and earnest workers. Beginning his active life as a maker of optical instruments, he secured before the termination of it an international reputation in its practical and theoretical fields. In early life, too poor to buy a telescope to gratify his desire to study the skies, he made the lenses for one, working at this task at night while he earned his living in a mill by day. It is not without interest that we read that his wife assisted him to the extent of her ability in his scientific labors, and by her inspiration and encouragement he was helped in his triumph over failures and occasional despair.

Later, when he took up, as a business, the manufacturing of lenses, he found that efficiency in that field would not spell financial success, for those who are interested in astro-physics are few and far between, and the difficulties and risks of the making of large, high-grade optical instruments are numerous.

When the question arose of establishing a standard of length more durable than the standards deposited respectively in London (the yard) and Paris (the metre), Michelson suggested that the wave-length of light might serve as datum, unchangeable and indestructible. The construction of the instrument for this purpose was committed to Brashear, and it was successfully carried out, an extremely accurate and delicate apparatus being produced.

Among his greatest triumphs in telescope construction are the 72-inch parabolic mirror for the Dominion Observatory, Victoria, Canada; 37-inch parabolic mirrors for the Lick Observatory and University of Michigan; a 16-inch photographic doublet for the Koenigsthal Observatory, Heidelburg, Germany. He has designed and constructed many spectroscopes for astronomical purposes, and made the speculum plates for Professor Rowland's diffraction gratings.

He was honored by degrees from institutions of learning of highest standing, among which was the degree of Sc.D. from Princeton University. He was member of many learned societies and was elected an honorary member of The Franklin Institute on April 4, 1919.

Doctor Brashear's opportunities were extended by the attention that he attracted from Langley, through whose efforts he was enabled to move to Allegheny, where he set up a shop for lens grinding, which was the beginning of the firm afterwards of world-wide reputation.

It is interesting to note that he was not neglectful of his less fortunate fellow men and women, for some years before his death he founded the Brashear Settlement Association, which has its headquarters in the house in which he spent his earlier years.

He died on April 8, 1920, having reached within a few months of the Psalmist's utmost span of life. His wife died a few years before him, and their joint tomb bears the beautiful epitaph written by Brashear: "We have loved the stars too fondly to be fearful of the night."

H. L.

LIBRARY NOTES.

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Pennsylvania Department of Labor and Industry, Third Annual Report, 1916. Harrisburg, Penna., 1918. (From the State Librarian.)

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Stowell Company, Catalogue of the Malleable Sprocket Chain. South Milwaukee, Wis., no date. (From the Company.)

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Whitney Window Corporation, Catalogue of Whitney Casement Window Hardware. Minneapolis, Minn., no date. (From the Corporation.)

Wilmot Engineering Company, Catalogue of the Keystone Rivetless Chain. Hazleton, Pa., no date. (From the Company.)

Worthington Pump and Machinery Corporation, Catalogue of Condensing Apparatus. New York, N. Y., 1920. (From the Corporation.)

BOOK NOTICES.

AIRPLANE PHOTOGRAPHY. By Herbert E. Ives, Major, Aviation Section, Signal Officers' Reserve Corps, U. S. A. 413 pages, contents and index. 208 illustrations, 8vo. J. B. Lippincott Company, Philadelphia and London, 1920. $4.00 net.

Taking up this book for examination, on May 6, 1920, the reviewer is reminded that it is "Langley Day," the twenty-fourth anniversary of the first flight ever made by a heavier than air machine under its own power developed in the machine itself. It was on May 6, 1896, that Samuel Pierpont Langley succeeded in operating his "aerodrome" on the Potomac River, near Quantico, in a sustained flight for about 3300 feet, at a height of about 75 feet and a speed of about 20 miles per hour. These figures seem trifling now when we are familiar with transoceanic and transcontinental journeys, soaring in the empyrean above the tops of the highest mountains, and with speeds double that of the average express train, but the difficulties against which Langley strove were enormous, for he had not only to develop the mathematics and mechanics of flight, but to encounter a vast amount of antagonism both from the ignorant and the learned. Most persons in control in the government of the United States regarded Langley as a dreamer and sneered at his efforts. This is what might have been expected, for the mass of the community has no respect for or interest in pure science, but the more bitter experience was the disapproval of learned men. Lord Kelvin and Doctor Newcomb said that the flight of a heavier than air machine as large as an ordinary bird was impossible, yet at the time these statements were made the mathematical and practical demonstrations of the possibility of such flight were available to all.

The book before us does not deal with either the history of the development of the flying machine or with its physics or construction. It is devoted to that remarkable and valuable development, perhaps the most important application, the photography of the district covered in the flight. It needs no words to inform us of the great use that the airplane has been in war, and that one of the most important of its uses was

the securing of photographs of the enemy's works and movements. Photographs of this type are too familiar to need description. Doctor Ives was exceptionally well qualified to take a large part in the operation of the photographic department of the Signal Corps, and the present work, which summarizes in plain language the methods, difficulties and results of the work, will be a welcome addition to the literature of the subject. He has not overlooked the application of airplanes to the arts of peace, and devotes a chapter to the probable future developments in apparatus and methods, to the technical and pictorial uses of the machine and to its use in exploration and map making. It seems that the former application, namely, exploration, will be of special value, since it will enable correct geographical and geophysical data to be obtained in parts of the world in which conditions of travel, hostility of inhabitants or the dangers from disease make the ordinary methods of exploration difficult or practically impossible.

The author is to be commended for the excellence of the text and convenience of arrangement, and the printer for the liberal use of illustrations of a very high class.

HENRY LEFFMANN.

LABORATORY MANUAL OF ELEMENTARY COLLOID CHEMISTRY. By Emil Hatschek. 131 pages, contents, indexes and 20 illustrations, small 8vo. Philadelphia, P. Blakiston's Son & Company. $2.00, net.

The author of this work is so well and favorably known in connection with the subject of the colloidal state, that one may expect that it will be a valuable addition to the literature of the subject, and examination does not disappoint. In a compact form a large number of procedures for the preparation of the several classes of colloidal conditions are described, also many illustrative experiments on the nature and properties of these conditions. The data are based throughout, the author informs us, on personal experience, not only in carrying out the processes, but in teaching them, the latter being, indeed, one of the best methods of studying a subject. It is related in a recently published work, that Van t'Hoff once said, in public, that he did not understand Avogadro's postulate until it became his duty to teach it. The book will be a great advantage to the older class of teachers to whom the difficulties of illustrating and explaining this now important subject have been a serious matter.

In connection with the general descriptions of apparatus and methods, considerable attention is given to the standards of purity of the reagents, and the resisting power of the containers, among which we note the caution that test-tubes which in a brief period cause distilled water placed in them to turn phenolphthalin pink are not uncommon among laboratory supplies, and should not be used in this work. Caution in regard to thorough cleaning is also given.

The work is a valuable addition to the literature of a growing and important department of physical chemistry.

HENRY LEFFMANN.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS. Report No. 43. Synopsis of Aeronautic Radiator Investigations for the Years 1917 and 1918. Preprint from the Fifth Annual Report. 8 pages, illustrations, quarto. Washington, Government Printing Office, 1920.

The report outlines the factors to be considered in studying radiators, and discusses briefly characteristics of core structure and conditions under which the radiator is used. Properties that indicate the performance of the radiator are defined, and their relations to each other are pointed out. Performance curves for four representative types show how the properties vary with speed of flight. Some of the more important conclusions of the investigations are pointed out, including curves showing the effect of rate of water flow on heat transfer, and a method for estimating the performance of a radiator at altitudes.

Report No. 69. A Study of Airplane Ranges and Useful Loads. Preprint from the Fifth Annual Report. 29 pages, illustrations, quarto. Washington, Government Printing Office, 1920.

This report considers the question of possible ranges and useful loads for airplanes from two points of view. A sample calculation is made, using a step-by-step method, and a theoretical solution is carried through and the two results compared. It is shown that the two methods check each other in a very satisfactory way, which is fortunate, as the theoretical formulæ may be used with confidence, and their numerical application is a very simple matter.

It is quite evident that the factors upon which large range depends are the lift over drift ratio for the complete machine, the ratio of weight empty to weight fully loaded, the fuel consumption per horsepower hour of the motor and the efficiency of the propeller. The qualities of an airplane are completely characterized by these factors. The theoretical solution gives explicitly the way these factors contribute to its range and load carrying properties.

The question of range with useful load is considered, including a flight to an objective, delivery of load and return without refueling, this problem being of interest with respect to bombing. It is completely solved, and a very practical and expeditious method is derived for all possible cases. Among other results are equations giving-time to attain a given distance-time required to use up a given weight of fuel and distance corresponding to a given weight of fuel. The effects of climb at start and glide at end of flight are shown to be practically negligible.

Comparisons of high speed flight and flight with minimum power are made with greatest range or economical flight, especially with regard to load carrying range and time. A special method for determining the effect of the wind from a single curve for all wind speeds, either with or against the direction of flight, is derived and applied, and the effect of wind on angles of incidence for most economical flight is determined. Most of the formulæ are applicable not only to range flights at most economical angles, but also flight at any angle of incidence.

Report No. 71. Slip-stream Corrections in Performance Computa-

tion. Preprint from the Fifth Annual Report. 12 pages, illustrations, quarto. Washington, Government Printing Office, 1920.

This publication is concerned with the variation of slip-stream velocity with rate of advance of a propeller, and treats the subject both from the experimental and the analytical standpoint. The experimental portion is based on Eiffel's work. The relative increase in slip-stream velocity is much less rapid than that in air-speed, and the slip-stream correction, therefore, falls off as the air-speed increases. A method, based on the momentum theory of propulsion, is given for determining the slip-stream correction for any given propeller under any conditions. The curve of slip-stream velocities thus determined by theory checks extremely well (within 2 per cent.) with the experimental curve for the one propeller for which data are available.

Report No. 75. The Aerodynamic Properties of Thick Aerofoils Suitable for Internal Bracing. Preprint from the Fifth Annual Report. 26 pages, illustrations, quarto. Washington, Government Printing Office, 1920.

This report deals with the results of a series of tests conducted at the Massachusetts Institute of Technology wind tunnel, with a view to developing aerofoil sections thick enough to permit of internal bracing and the use of cantilever wings without any external bracing of the airplane wing truss. The sections tested were based on the Durand 13, and were varied in section form, in thickness along the span, and in chord along the span. Tapering both in thickness and in chord was found to be highly beneficial to efficiency, and some of the wings developed gave L/D ratios practically as high at angles corresponding to very high speeds of flight as the best of the wing sections for normal type, together with very much higher maximum lift coefficients.

Report No. 76. Analysis of Fuselage Stresses. Preprint from the Fifth Annual Report. 15 pages, illustrations, quarto. Washington, Government Printing Office, 1920.

Prepared by the staff of the Committee at Langley Field, this report is concerned chiefly with the assumptions to be made as to the loading on fuselages. A typical "stick-and-wire" fuselage is analyzed for four different sets of assumptions as to landing loads and for three different conditions in flying. In treating flying conditions, all the inertia loads are included, and a single diagram is drawn including all the members from nose to tail. The inertia loads due to angular accelerations are shown to be very important and to decrease the stresses in the rear of the fuselage by more than 50 per cent. in some instances.

The discussion of stress analysis by graphical methods is, of course, applicable only to "stick-and-wire" fuselages, but the treatment of inertia, damping, and tail loads is equally useful for veneer and monocoque designs. As a result of this investigation of loads certain recommendations are made as to the distribution of loads in sand-load testing of fuselages.

Copies of the above reports may be obtained from the Committee.

R.

PUBLICATIONS RECEIVED.

U. S. Bureau of Mines: Bulletin 78, Approved Explosion-proof Coal-cutting Equipment, by L. C. Ilsley and E. J. Gleim. 53 pages, illustrations, plates, 8vo. Washington, Government Printing Office, 1920. Bulletin 183, Abstract of Current Decisions on Mines and Mining Reported May–August, 1919, by J. W. Thompson. 167 pages, 8vo. Washington, Government Printing Office, 1920.

U. S. Coast and Geodetic Survey: Terrestrial Magnetism. Alaska magnetic tables and magnetic charts for 1920, by Daniel L. Hazard, Assistant Chief, Division of Terrestrial Magnetism. Special Publication No. 63. 31 pages, maps, 8vo. Washington, Government Printing Office, 1920. Price, twenty cents.

University of Illinois Bulletin: The Relation Between the Elastic Strengths of Steels in Tension, Compression and Shear, by Fred B. Seely and William J. Putnam. Bulletin No. 115, Engineering Experiment Station. 49 pages, illustrations, 8vo. Urbana, Engineering Experiment Station, 1919. Price, twenty cents.

Engineering Experiment Station, University of Washington: Engineering Experiment Station Series Bulletin No. 5. Electrometallurgical and Electrochemical Industry in the State of Washington, by Charles Denham Grier. 43 pages, 8vo. Seattle, University, 1920.

Panchromatism: Second edition, revised and enlarged. 32 pages, illustrations, plates, colored frontispiece, 8vo. London, Ilford, Limited. No date.

The Fabric of Cosmic Energy: The suggestion of a substitute for the space-filling ether, by John Leuthold. 12 pages, 24mo. Breckenridge, Colorado. Reprinted from the Summit County Star, 1920.

Potash. (*U. S. Geological Survey, Press Bulletin No. 445.*)—Silicate rocks, which are widely distributed over the United States, contain potash in an insoluble combination and in a form which is not available for industrial use, but they are gradually decomposed on exposure to the weather. The potash, thus rendered soluble, is dissolved by rain or ground water, and it finally reaches the ocean or inclosed drainage basins through streams or is absorbed from percolating water by clays.

River waters of North America contain an average of 281 parts per million dissolved salts, of which an average of 1.77 per cent. is potassium. They carry annually to the ocean 8,339,800 metric tons of potassium, and the river waters of the world carry 57,892,000 metric tons. The annual precipitation of potassium in insoluble form in the ocean is 50,320,000 metric tons, leaving an annual gain of potassium by the ocean of 7,662,000 metric tons. The total potassium content of the ocean is 510,800,000,000,000 metric tons. Ocean water contains 3.30 per cent. of salts, of which 1.11 per cent. is potassium, corresponding to 1.38 per cent. of potash (K_2O).

CURRENT TOPICS.

New Methods for Cheap Fuels. (*American Chemical Society News Service.*)—Costs of heat and power are likely to be much reduced by the use of the new colloidal fuel described at the recent spring meeting of the American Chemical Society, held in St. Louis. A combination of finely divided coal dust and of waste from stills, which is held together in emulsion form by soap-like substances, this fuel will undoubtedly have an important effect upon industry.

In view of the many inquiries made from all parts of the country, the paper describing this new factor in industrial economy is produced in full in the current number of the *Journal of Industrial and Engineering Chemistry*. Its author, Mr. Jerome Alexander, of New York City, gives due credit to all concerned in the development of this latest application of colloidal chemistry—that branch of science which relates to substances in a state of fine suspension, such as may be found in emulsions and gelatins.

"What promises to be one of the most far-reaching advances made under the stress of the recent war," writes Mr. Alexander, "when necessity literally was the mother of invention, is the discovery that by means of a suitable fixation, or peptizing agent, and suitable treatment, very large percentages of cheap tars and finely powdered coal waste may be dispersed in fuel oil with a sufficient degree of permanence to enable the mixture to be stored, piped, atomized and burned practically like fuel oil itself.

"Since it will at one stroke relieve the drain on the earth's rapidly diminishing stores of petroleum, as well as lead to the efficient utilization of all kinds of coal waste, such as culm, screenings and dust, inferior fuels such as peat and lignite, and even cellulose waste, such as slabs and sawdust, this new composite fuel may be hailed as a powerful factor in the conservation of our natural resources and as a lasting benefit to mankind.

"Realizing the vital importance of the Allies' oil supply in the conduct of naval, military, and manufacturing operations, the German submarines bent every effort to destroy tankers. Marshal Foch is said to have cabled America: 'If you don't keep up your petroleum service, we shall lose the war.' While the Allies' navies were dealing with this peril in a most decisive fashion, Lindon W. Bates, of New York, head of the Engineering Committee of the Submarine Defense Association, with the assistance in laboratory matters of Dr. S. E. Shepperd and other chemists of the Eastman Kodak Company, courteously opened to him, developed a colloidal fuel which, by practically doubling

the usefulness of every oil cargo, would of itself have materially assisted the defeat of the efforts of the Hun.

"Coal or other combustible solid," says Doctor Alexander in explanation, "is prepared for dispersion by being pulverized so that about 95 per cent. passes through a sieve which has one hundred meshes to the square inch. This means, of course, that by far the greatest weight is in particles hundreds and hundreds of times larger than colloidal dimensions."

Doctor Alexander also described how this new development in chemistry was employed by war vessels in creating colloidal clouds for smoke screens in order to outwit the pursuing submarines.

Neon Lamps in Stroboscopic Work. (*Proc. Cambridge Philos. Soc.*, 1920, vol. xix, 300.)—F. W. ASHTON describes the construction and operation of a lamp containing neon under reduced pressure, which is especially satisfactory for illumination of a moving object by flashes of very short duration. The rate of interruption can be controlled by an electrically driven tuning-fork, so that the efficiency of any given method will depend on the shortness and brightness of the flashes, and the character of the light in its action on the eye. Experiments with naked Leyden-jar sparks having been found unsatisfactory, attention was turned to neon, and a form of lamp was designed and filled with the gas. This turned out to be a great success. Ashton describes in detail the form of lamp finally adopted, which cannot be made clear without the illustration. Apart from accident, the lamp is serviceable until the pressure of the gas becomes too low for the spark to light it adequately. The life appears to consist of two distinct periods. The first is during the time when the chemically active impurities derived from the electrodes and walls of the tube are being slowly and completely eliminated (as far as spectroscopic tests go), and the second period is one in which the sputtering of the cathode occurs, and the neon itself begins to disappear. During the first period the luminosity steadily increases, remaining almost constant during the second period until rapid decrease occurs. So far the best results have been obtained from a batch of lamps filled at 10 mm. pressure, some with pure neon, some with a mixture of neon and 10 per cent. of helium. One of the latter type had a working life of over 3000 hours, the helium disappearing from the spectrum after the first few hundred hours.

Ordinary gases give but feeble illumination, carbon monoxide being about the best. Helium gives a bright discharge, but not nearly so satisfactory for visual work as neon. The brilliant orange-red glow of neon is composed almost entirely of lines in the region 5700–6700 A.U., and is in such striking contrast to sunlight that stroboscopic observations can be made in daylight, if necessary. Ashton, referring to the growing technical importance of neon, advises that engineers of liquid air production

should consider the erection of fractionating plants for obtaining the gas from the air which contains 0.00123 per cent. by volume. Such a plant now exists in Paris, operated by George Claude, to whom the author of the paper was indebted for the neon used.

H. L.

Bureau of Mines' New Director.—The nomination of Dr. Frederick G. Cottrell as Director of the Bureau of Mines, and the recent award to him, by the Chicago section of the American Chemical Society, of the Willard Gibbs Medal, calls special attention to the great service that Doctor Cottrell has rendered to chemical industry by the development of the method of removing suspended matters from gaseous products of many mining and manufacturing operations. Doctor Cottrell, now forty-three years of age, graduated at the University of California in 1893, studied abroad, and subsequently was connected with his *alma mater* in the teaching of physical chemistry. He was consulted in regard to the problem of removing fumes from the discharges of a sulphuric acid plant, at a copper smelter. Much trouble had arisen about the matter, the state authorities threatening to close the works unless the nuisance was abated. The plan he adopted, which was successful, was to place at the bottom of the flues chains carrying powerful electric currents, which caused the particles to fall, clarifying the gases. The process was extended to many other industries and will be very useful in decreasing the offensive character of many plants. Doctor Cottrell took out patents, but arranged that all profit therefrom should go to a non-dividend paying company, "The Research Corporation," devoted to the encouragement of research.

H. L.

The Albedo of the Contents of the Air. L. WEBER. (*Ann. d. Phys.*, vol. li, 1916.)—When a beam of light traverses a darkened room, a considerable quantity of light is diffusely reflected from the motes in the path of the light. In the open air motes are present and the illumination is stronger. Hence the diffused light must be produced even if it is not so obtrusive.

For the measurement of the diffuse light a type of photometer was used in which the observer looked through a layer of air toward a cavity from which no light was reflected back into the instrument. Light from a milk-glass globe, illuminated by daylight, was reflected so that it could be directly compared with the light reflected from the layer of air. The experiment led to the determination of the depth of air which would furnish an intensity of light equal to daylight. On a very clear day this distance was found to be about 50 km. and on a cloudy day 3.3 km. Absorption is, however, not taken into account in the calculations.

G. F. S.

United States Power Program. (*U. S. Geological Survey Press Bulletin*, No. 435, December, 1919.)—Under the war demand for fuel conservation the hydraulic engineers of the United States Geological Survey, Department of the Interior, served the Fuel Administration in a field study of power problems.

A power survey of the United States was begun, and at the end of the war Secretary of the Interior Lane asked of Congress two appropriations, one of $50,000, for continuing this power survey over the whole United States, and the other of $200,000, for an extensive survey of the industrial zone of the East, where power requirements are most congested. At present in the central power plants of the country water power carries only about 40 per cent. of the load, while the total fuel requirement for steam-generated power, including that of the railroads, is not less than 800,000 tons daily. A power program that calls for the immediate and full development of every available and feasible water power, moreover, means saving both in coal and in man power, and with this purpose of securing the double conservation, the investigation has been proposed. The first step is to get the facts for the country as a whole and particularly for the North Atlantic industrial district.

This "super-power" project, which engineers agree seems wholly practicable but which can be regarded as now only in the vision stage, is to pool the power supply for the whole industrial area between Boston and Washington, in which is concentrated one-fourth of the power-generating capacity of the country. Such a unified power system would tie together properly located steam-electric and hydroelectric plants—old plants that are efficient as well as new plants—in a great power main from which would flow the energy to serve a score of railroads, hundreds of public-service companies, thousands of mills and factories, and millions of homes.

The subject is necessarily one for interstate investigation and is linked with the national problem of providing adequate transportation facilities. Electrification of our railroads would effect fuel economies of more than 50 per cent. in coal consumed, not to mention the greater efficiency of electric traction through increasing road capacity. Equally important, moreover, is the relation of cheaper power to American industry. As stated by Secretary Lane in a letter transmitting the estimate for this appropriation: "Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets, maintaining at the same time the American standard of wages and living."

Some Inorganic Poisons were discussed by ALICE HAMILTON, of the U. S. Bureau of Labor Statistics, in a lecture delivered at the Harvard Medical School, and published in the *Chemical Trade Journal and Chemical Engineer*, 1919, lxv, 365–367. The lecture deals primarily with industrial poisoning. Arsenical poisoning may occur in the manufacture of certain insecticides, such as lead arsenate and Paris green. The workmen are best protected by plugging the ears and nostrils lightly with cotton, smearing the face with a bland ointment, wearing clean work clothes each day, and use of a full shower bath at the end of each day's work. Poisoning by arsine (hydrogen arsenide) may take place when moisture acts on ferrosilicon which contains 40 to 60 per cent. silicon; the ferrosilicon contains as an impurity calcium arsenide which reacts with water under these conditions to liberate arsine. Antimonial poisoning has not been reported among workers in the printing trade; its occurrence among rubber workers is uncertain, though possible. Golden and crimson sulphides of antimony—really mixtures of its pentasulphide, trisulphide and oxysulphide—are used in large amounts in the manufacture of rubber; human gastric juice dissolves approximately 8 per cent. of the antimony present in the crimson sulphide, and about 3 per cent. of the antimony present in the golden sulphide. Mercurial poisoning may attack mercury thermometer makers, and workmen who manipulate mercury vacuum pumps in the manufacture of incandescent lamps and similar apparatus. Since mercuric nitrate is used in the preparation of felt for hats, mercurial poisoning may occur among workers in that industry. Use of carbon disulphide in the rubber industry of continental Europe has caused many cases of poisoning. In the United States, poisoning by carbon disulphide vapors has been observed among workers in the manufacture of artificial silk from cellulose, carbon disulphide, and caustic soda. While poisoning by phosphorus is painful and disfiguring, only a small proportion of the workmen are attacked, and the mortality is low, 15 to 20 per cent. Since the abolition of the white phosphorus match, but little white phosphorus is used in American industries; during the Great War it was used in an incendiary projectile. Ferrosilicon may evolve phosphine (hydrogen phosphide) as well as arsine.

J. S. H.

American Philosophical Society, Papers Presented at the Meeting of April 24, 1920. L. A. BAUER.—*The Relation of the Recent Solar Eclipse to the Einstein Theory.*—The eclipse of 1919 was peculiarly favorable for testing this theory because several bright stars were near the sun at the time. By the theory of gravitation advanced by the Swiss scientist these stars should have appeared to be displaced 1.74 seconds along lines joining them to the sun. In fact, early reductions of the results showed that in general they were

not displaced along this line, but were displaced in other directions about 2 secs. When Doctor Bauer took into account second order terms in correcting for atmospheric refraction, not only was the angle of displacement calculated from the observations reduced to 1.77 secs. but in addition the departure from the radial directions disappeared altogether.

D. C. MILLER.—*Velocity of Air Waves from Explosions.*—When a steamer travels in quiet water a water wave travels in advance of it. Similarly a rapidly moving projectile is preceded by an air wave. As this keeps ahead of the shell and as the latter travels faster than sound, it follows that the wave travels faster than sound. It spreads out to the sides. Professor Miller finds by experiment that, even when the nose-wave has a velocity of 2720 ft. per sec., the lateral parts of the wave, distant only two or three lengths of the projectile from the foremost part, travel with normal velocity.

The wave which leaves the muzzle of a 14-inch gun at first moves faster than ordinary sound waves, but at a distance of about 800 ft. its velocity comes down to normal.

Arthur G. Webster in discussing this paper showed a slide in which variations of air pressure caused by the passing of a bullet were recorded. The frequency was about 3000 per sec. This accounts for the whistle of the bullet.

J. B. WHITEHEAD.—*Uses of the Electrical Corona.*—When a sudden strain is thrown upon a transmission line by lightning or otherwise it has been noticed that lines operating with very high voltage—and in consequence with a corona—suffer less damage than those at lower voltages. It is proposed to have the voltage of the line not at, but a little below the point necessary for the development of the corona. Then when a sudden rise of electrical pressure occurs, the corona will form and will act as a sort of safety-valve by dissipating energy.

A second use is for the measurement of crest values of high A. C. voltages. With round wires the corona appears at definite voltages, depending on the diameter of the wire and on the pressure and temperature of the air. An instrument has been devised by which applied potentials up to 400,000 volts can be measured from the known connection of the corona with the three variables. The corona is detected by its causing the air to become a conductor, thus enabling a current to flow through a galvanometer. In a confined space the corona is accompanied by a loud noise.

H. C. HAYES.—*The M-V Hydrophone.*—This instrument, which was designed for the detection of submarines, can locate the direction along which sounds reach it through water with an accuracy of two degrees. When the *Von Steuben* with a hydrophone installed on board left New York, the craft in the harbor were located and the lightships, which were giving sound signals, were picked up before they could be seen. Sounds emanating from the *Nantucket* lightship were heard for two hours, the shortest distance being 32

and the longest 40 miles. Later in the voyage vessels could not be detected. In fact, the sound of the *Von Steuben's* own propellers was inaudible. It developed that the hydrophone is useful only in shallow water. Only such sounds as are reflected from the bottom are heard.

Depths of water can be measured by the same instrument up to distances equal to three times the length of the vessel on which it is mounted. The accuracy of the measurement increases as the depth grows less. On a voyage during which the continental shelf was crossed soundings were made by using the hydrophone and then compared with the results obtained by a sounding machine, by hand and from a chart. When any two of the last three agreed, then the hydrophone results agreed also.

Since the direction of fixed objects, such as lightships, can be determined and in addition the depth of water can be measured, this instrument promises much usefulness in navigation. To test this a run was made in a fog with a submarine from Salem, Mass., to Portland, Me., and back to the southern coast of New England. The voyage was accomplished in safety and the location of the vessel was determined with surprising accuracy.

G. F. S.

Physiological Action of Nitrobenzene Vapor on Animals.—WALLACE LARKIN CHANDLER reports the results of a research on this subject in *Memoir 20 of the Cornell University Agricultural Experiment Station*. Nitrobenzene (oil of mirbane) exerts a toxic action when ingested, inhaled, applied to the skin, or injected beneath the skin. The lethal dose, *i.e.*, the dose required to produce death, is extremely variable. The digestive functions may be disturbed, and asphyxia may be produced by direct action on the blood. The red blood cells are altered; and the hæmoglobin is changed to methemoglobin. However, most of the symptoms of poisoning by nitrobenzene are due to its action on the brain, for it produces degeneration of the Purkinje cells of the cerebellum. The size of the lethal dose and the length of the latent period, which occurs between the actual poisoning and the onset of the symptoms, depends on the amount of fat in the blood and the body of the poisoned animal; the nitrobenzene enters the blood, and then is absorbed by the body fat; as its concentration in the blood decreases, it is given up by the body fat to the blood fat, carried by the latter to the brain, and deposited in the brain cells. The following conclusions are reached: Nitrobenzene cannot be safely used for the fumigation of animals to destroy their external parasites, and should not be used as an ingredient of flavoring extracts, or as a perfume in soaps and toilet articles, or as a solvent in shoe polish and floor wax. It should be given serious consideration as an industrial poison in the dyestuff and related industries.

J. S. H.

Distribution of the Chemical Elements.—Geochemists have calculated the percentage by weight of the different elements in the known crust of the earth, including the rocks, water, and atmosphere. INGO W. D. HACKH (*Science Progress*, 1920, xiv, 602–607) has used these figures as the basis of his calculations. If the per cent. of each element, which is present, be divided by its atomic weight, the quotient shows the relative proportion of its atoms in the crust. Of the 25 elements, whose atoms are most abundant, those of bromine are least abundant; and the relative proportion of bromine atoms was therefore taken as unity; the other elements then fell into the following order of magnitude with respect to the occurrence of their atoms:

O	249,850	Mg	6,835	Ti	714	N	171	V	23
H	75,312	Ca	6,422	Cl	451	Mn	116	Li	22
Si	72,860	Fe	5,982	F	421	Ba	46	Sr	16
Al	21,528	K	4,660	P	283	Cr	46	Zr	13
Na	8,200	C	1,199	S	274	Ni	26	Br	1

Hydrogen thus follows directly after oxygen with respect to the relative occurrence of its atoms.

J. S. H.

The Dissipation of Heat by Various Surfaces in Still Air. T. S. TAYLOR. (*Phys. Rev.*, March, 1920.)—Three vessels of sheet tin, 10 cm. in diameter and 50 cm. long, were made. One was left bare, one was covered closely with sheet asbestos 0.33 mm. thick and the third was covered loosely with the same material. All three were filled with hot water and allowed to cool under similar conditions. The result was obtained that the bare vessel lost only 70 per cent. as much heat per minute as the loosely covered one and 63 per cent. as much as the tightly covered vessel. The effect of dusting the surface with coal ashes was to slightly increase the radiation from the bare surface and to diminish to a somewhat greater extent the loss from the tightly covered vessel.

G. F. S.

Variation of Transparency to Total Radiation with Temperature of Source. S. L. BROWN. (*Phys. Rev.*, March, 1920, p. 217.)—Glass, rock salt, mica, celluloid and paraffin were examined. In all the transparency for total radiation increased markedly as the temperature of the radiating body rose from 200° to 1200° C. For glass the amount transmitted at the lower temperature was 5.8 per cent. and at the higher 61 per cent. For rock salt the corresponding numbers are 35 and 50.5. Glass alone shows a departure from the general rule by having a minimum transmission at 300°. Whether heated or cooled from this temperature its transmission increases.

G. F. S.

The Nuclei of Atoms and the New Periodic System. W. D. HARKINS. (*Physical Review*, February, 1920.)—Formulæ are given for the composition of the atoms and of the nuclei of the first 27 elements and of the radio-active elements. An atom of sulphur is given as consisting of 8 helium atoms, while its nucleus is made up of the same number of helium nuclei. Nothing but helium and hydrogen atoms appear in the formulæ for atoms, but in the nuclei there are also beta particles in addition to the nuclei of the two elements just mentioned. In general the nuclei of the even numbered light elements consist altogether of helium nuclei, while the odd numbered elements have in their nuclei an additional group, consisting of 3 hydrogen nuclei and 2 beta particles. The elements from 28 to 80 in atomic number do not fall in with this scheme, and it is suggested that they may consist of mixtures of isotopes.

"In a note appended at the time of correcting the proof for this paper, the writer states that his latest atomic weight results seem to indicate that he has obtained an experimental separation of chlorine into isotopes."

G. F. S.

Nature of the Process of Ionization of Gases by Alpha Rays. R. A. MILLIKAN, V. H. GOTTSCHALK and M. J. KELLY. (*Phys. Rev.*, March, 1920, p. 157.)—Alpha rays from radium bombarded the molecules of air, carbon dioxide, carbon tetrachloride, methyl iodide and mercury dimethyl. Thus atoms of H, C, O, N, Cl, I and Hg, with a range of atomic weight from 1 to 200, were traversed by the rapidly moving rays. The residues of the ionized atoms were caught on oil drops and their electrical charges measured. This was done in 2900 cases of which only five corresponded to double charges and none at all to triple or larger charges. "The results prove that, at least, 99 times out of 100, ionization by an Alpha ray, in the case of each of the gases and vapors studied, consists in the detachment of a single elctron from a molecule."

G. F. S.

Digestibility of Chicken Skin.—EDWARD F. KOHMAN and H. A. SHONLE (*Journal of Biological Chemistry*, 1920, xli, 469–472) have made metabolism experiments on human subjects concerning the utilization of the proteins or nitrogenous constituents and the fat of the skin of the common fowl. The results showed that, when 65.1 to 67.5 per cent. of the nitrogen of the diet was supplied by chicken skin, the utilization of the nitrogen was as good as when the same proportion of the nitrogen was supplied by meat, eggs, and milk. The utilization of the ingested fat likewise was practically the same on the chicken-skin diet, and on the diet of meat, eggs, and milk.

J. S. H.

The Production of Power from Blast Furnace Gas. S. H. FOWLES. (*Electrician*, March 26, 1920.)—Sir Charles A. Parsons, Franklin medallist, "has estimated that the total available water-power in the British Isles is only 1½ million horse-power, and that England possesses only one per cent. of the water-power and 2½ per cent. of the total coal in the world." The blast furnaces of Great Britain annually waste a million horse-power. The following table compares the old method with the Halberg-Beth type of plant:

	Old Method	New Method
Gas made per furnace per hour	1,000,000 cu. ft.	1,000,000 cu. ft.
Gas used per furnace per hour	1,000,000 cu. ft.	550,000 cu. ft.
Coke per ton of pig iron made	23 cwt.	21 cwt.
Units of electricity generated per furnace per annum	None	6,870,000
Potash saved per annum	None	£6,000
Flue cleaning costs per annum	£1,000	None
Coal used per furnace per hour	0.5 ton	0.2 ton
Horse-power developed per furnace per hour	600	800

G. F. S.

Heat production during luminescence has been studied by E. NEWTON HARVEY (*Journal of General Physiology*, 1919, ii, 137–143). *Cypridina hilgendorfi*, a small crustacean, contains a compound luciferin and an enzyme luciferase, which oxidizes the luciferin to oxyluciferin in the presence of water and oxygen; this reaction is accompanied by the production of light, and is the cause of the bioluminescence of the living animal. Both the luciferin and the luciferase are soluble in water; and a solution may be prepared containing only one or the other of the two substances. A solution of luciferin was mixed with one of luciferase in a suitable apparatus, and the change in temperature noted. The results indicated that 1 gram of luciferin liberates less than 0.1 small calorie during the luminescence which accompanies its oxidation.

J. S. H.

Duration of Light Emission from a Radiating Hydrogen Atom. A. J. DEMPSTER. (*Physical Review*, February, 1920.)—Canal rays were shot through a hole from a discharge tube into a second tube with a much higher vacuum. After moving about 4 cm. beyond the hole the luminosity of the particles died out. From the Doppler effect exhibited by the rays the speed of the particles was found to be 90,000,000 cm. per second. Hence the time required for the light to die away beyond the hole was about five hundred-millionths of a second. The light was chiefly that of the beta line of hydrogen.

G. F. S.

Use of Cirrus Clouds in Forecasting the Weather. G. REBOUL and L. DUNOYER. (*Comptes Rendus,* March 22, 1920.)—The appearance of cirrus clouds has for a long time been known to be connected with the shifting of barometric pressures. The authors have subjected certain phases of this relation to the test of comparison over considerable lengths of time. In 93 per cent. of the cases it was true that the appearance of this type of cloud indicated a barometric depression in the neighborhood. In 82 per cent. of the cases the direction in which these clouds moved was toward the depression. The agreement in France was, however, much better for a motion from the west than in the opposite direction. In about 63 per cent. of the cases the cirrus clouds moved in the same general direction as the depression. Seventy per cent. of the times a great velocity in these clouds means a great velocity in the motion of the depression. The development of cirrus clouds in quantity means either that the depression is close at hand or that it is quite considerable in amount.

G. F. S.

Acid Solutions.—The relationship between the total acidity, the concentration of the hydrogen, and the taste of acid solutions has been investigated by R. B. HARVEY (*Journal of the American Chemical Society,* 1920, xlii, 712–714). Total acidity is the *total* amount of *free acid* present in the solution, and includes both that in the molecular state and that dissociated into its ions. Concentration of the hydrogen ion represents the hydrogen ions, and therefore measures the *dissociated free acid* present in the solution. Harvey's results indicate that the sour or acid taste of an acid solution depends on both the total acidity and the hydrogen ion concentration. It is therefore desirable that both these values be determined in the case of acid foods. The addition of sugar alters the taste, but does not change either the total acidity or the hydrogen ion concentration.

J. S. H.

The Constitution of Atmospheric Neon. F. W. ASTON. (*Phil. Mag.,* April, 1920.)—By the use of the Positive Ray Spectrograph it has been proved that neon contains two isotopes of atomic weights, 20.00 and 22.00 respectively. Their ratio by volume is 9: 1. There is some indication of the existence of a third isotope.

G. F. S.

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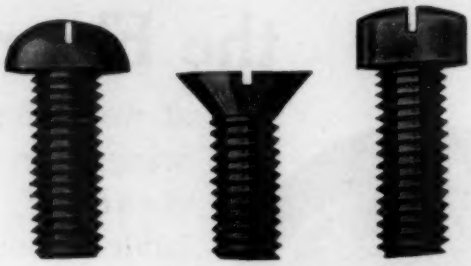

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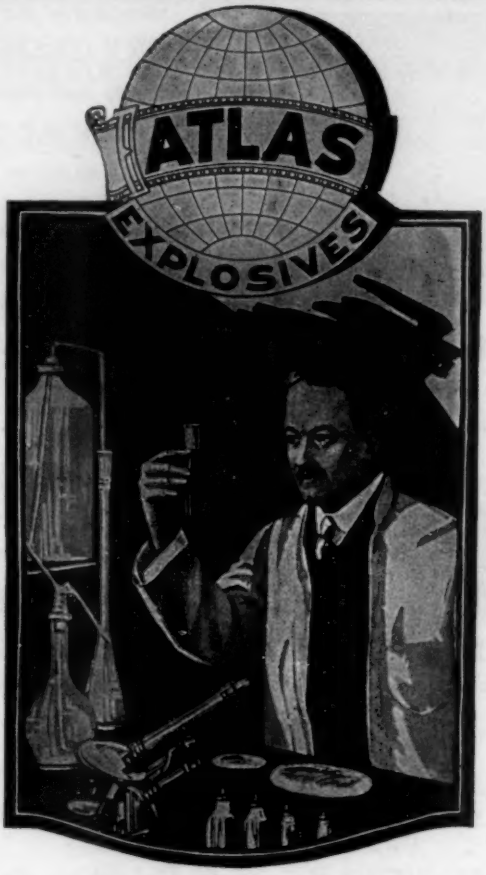

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INSTITUTE. Third Wednesday of each month (except June, July August and September), 8 P.M.

SECTION MEETINGS. Thursday Evenings (except week of Institute Meeting), 8 o'clock. October 1 to April 30.

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The Board of Trustees was formed in accordance with the following By-Laws passed in the year 1887:

> All Real and Personal Estate of the Institute which may hereafter be acquired by voluntary subscription or devise, bequest, donation, or in any way other than through its own earnings or by investment of its own funds, saving where the donors shall expressly provide to the contrary, shall be taken as acquired upon the condition that the same shall be vested in a Board of Trustees, who shall be appointed in the manner hereinafter indicated. Unless the title to such property shall be directly vested in said Board of Trustees by the donors, the Institute, by deed attested by the President and Secretary, which they are hereby authorized to execute and deliver, shall forthwith convey the same to said Trustees, who shall hold it in trust for the purposes specifically designated by the donors; or, if there shall be no specific designation, for the benefit of the Institute in the way and manner hereinafter provided, so that the same shall not, in any event be liable for the debts of the Institute.

This method of separating the *body holding* the principal of the various funds from the Board of Managers, the *spending body*, is an original idea of The Franklin Institute and it is hoped it will appeal to friends who may desire to create funds to further the objects of the Institute, and the various branches of science in which they may be interested.

MEMBERSHIP.

Terms and Privileges.

THE MEMBERSHIP OF THE INSTITUTE is divided into the following classes, viz.: *Resident Members, Stockholders, Life Members, Permanent Members, Non-resident and Associate Members.*

Any one interested in the purposes and objects of The Institute and expressing a willingness to further the same may become a member when proposed by a member in good standing and elected by the Board of Managers.

TERMS.—Resident members pay Fifteen Dollars each year. The payment of Two Hundred Dollars in any one year secures Life Membership, with exemption from annual dues.

STOCK.—Second-class stockholders pay an annual tax of Twelve Dollars per share, and the holder of one share is entitled by such payment to the privileges of membership.

PRIVILEGES.—Each contributing member (including non-residents) and adult holder of second-class stock is entitled to participate in the meetings of The Institute, to use the Library and Reading Room, to vote at the Annual Election for officers, to receive tickets to the lectures for himself and friend, to attend the Section meetings and to receive one copy of the JOURNAL *free* of charge, except associate members, who may not take part in elections.

PERMANENT MEMBERS.—The Board of Managers may grant to any one who shall in any one year contribute to The Institute the sum of One Thousand Dollars a permanent membership, transferable by will or otherwise.

NON-RESIDENT MEMBERS.—Newly elected members residing permanently at a distance of twenty-five miles or more from Philadelphia may be enrolled as Non-resident Members, and are required to pay an entrance fee of Five Dollars, and Five Dollars annually. Non-resident Life Membership, $75.00.

Contributing members, if eligible, under the non-resident clause, on making request therefor, may be transferred to the non-resident class by vote of the Board of Managers, and are required to pay Five Dollars annually.

ASSOCIATE MEMBERS.—Associate members are accorded all the privileges of The Institute, except the right to vote or hold office, upon the payment of annual dues of Five Dollars. This class of membership is limited to persons between the ages of seventeen and twenty-five years. Upon reaching the age limit they become eligible to the other classes of membership.

RESIGNATIONS *must be made in writing, and dues must be paid to the date of resignation.*

For further information and membership application blanks address the SECRETARY of THE INSTITUTE.